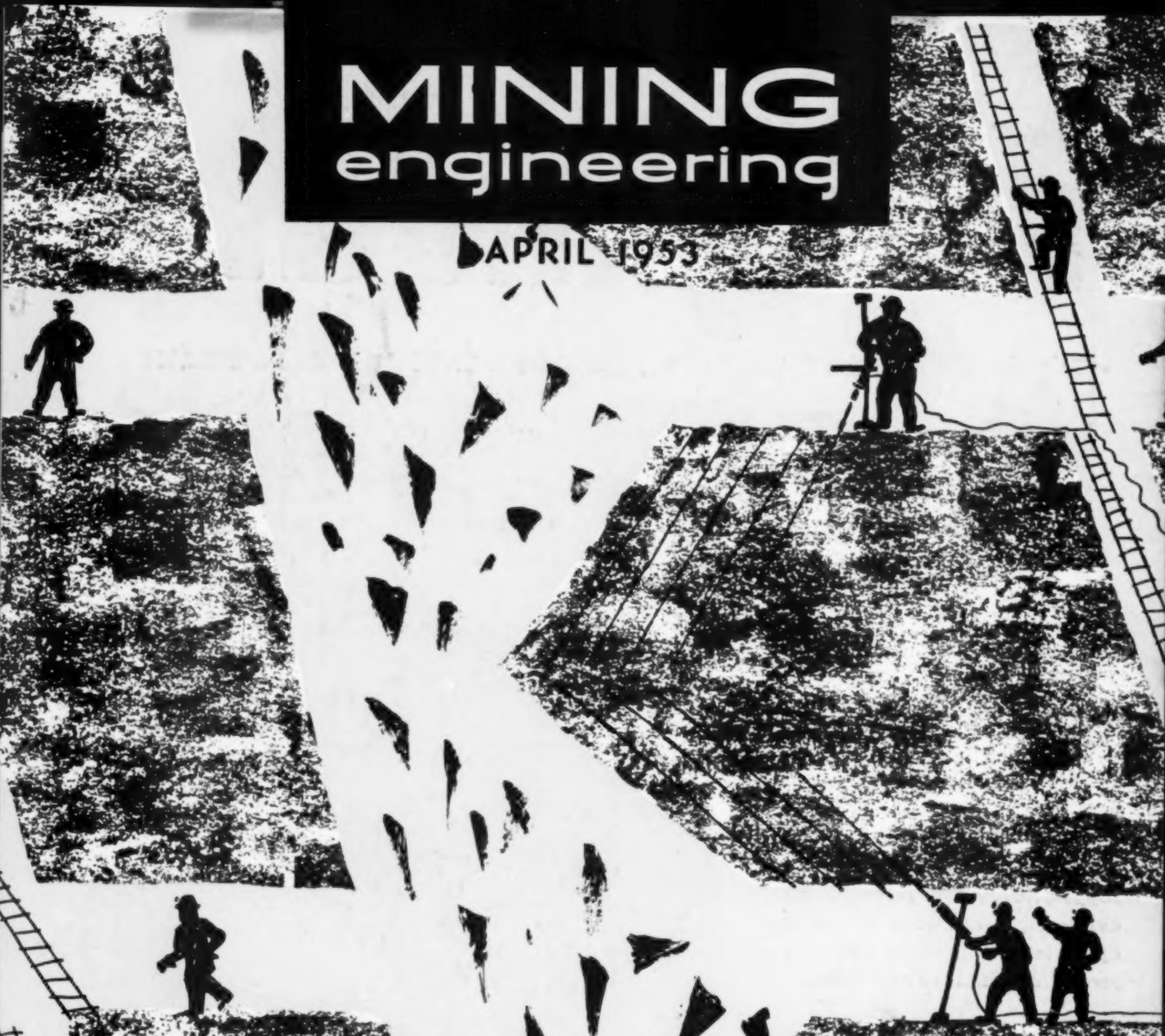
MINING engineering

APRIL 1953



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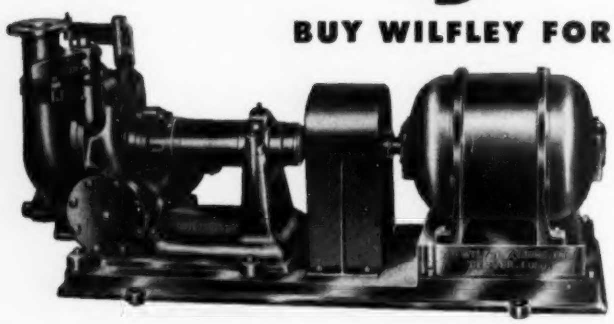

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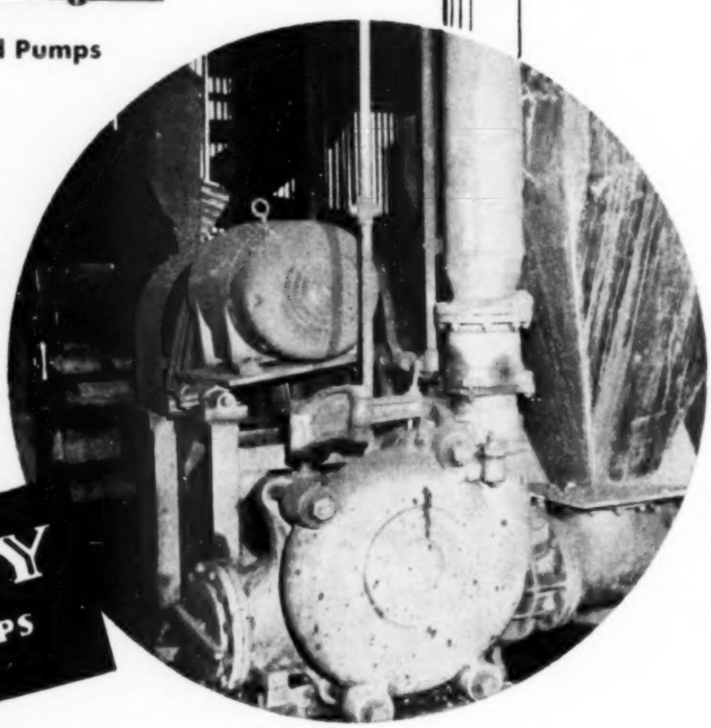
This Wilfley Model K *pump is extremely effective in heavy media circuit and thickener circuit work in coal washing operations. Specifically designed for rugged, heavy duty performance, delivering continuous, trouble-free operation at low cost without media loss, leakage or dilution.*



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MINING engineering

VOL. 5 NO. 4 APRIL, 1953

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COVER

Artist Herb McClure drew his cover this month embodying ideas of sub-level stoping methods which utilize ring drilling pattern from the subs.

FEATURES

ARTICLES

TRANSACTIONS

— Personnel Service —

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service, Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Mining Engineer - Geologist, 45, married, one child. Twenty years' experience all types underground mining. Five years' geological work making independent examinations. Location immaterial. Available thirty days notice. M-19.

Mining Engineer, B.S., 33, married, one child. Seven years' experience; completed one year training program open-pit and underground; sales service engineer for exports to South America; wide blasting experience; prospecting and exploring in Caribbean and South America. Spanish and Portuguese languages. M-16.

Mining Engineer, 47, married, noncitizen, presently residing New York. Twenty-three years experience coal, ore and stone industry in Germany and S. America, as manager and consulting engineer, underground and one of largest open-pit of Europe. Excellent background cost reduction, research, technical and administrative improvements and inventions. Accept position industry or research. M-20.

Coal Mining Engineer, graduate, married, no children; 25 years' experience, safety director, chief engineer, superintendent, general superintendent and manager with very progressive coal mine operations. Capable of supervising construction work of all kinds connected with coal mines. Have rather broad practical and technical knowledge all phases coal mine operations. Available 30 days notice. M-18.

Geologist, M. S. Excellent experience in seismograph interpretation and also in petrographic work. Desires position as subsurface petroleum geologist or research geology. M-17.

POSITIONS OPEN

Diamond Drill Superintendent for nine month term in Burma, single status; ten years' experience core drilling to depths of 1000 ft required. Primitive living conditions. Employment to start June. Salary, $1000 a month plus expenses. Y8333.

Sales Engineer, 28 to 35, mining or mechanical degree, with minimum of five years' experience or equivalent in selling in the New York area. Company manufactures mining equipment. Extensive traveling. Must have car. Salary, $5200 a year and expenses charged against a commission basis. Territory, New York and adjacent area. Y7916.

Mining Engineers, 2, young, with college background and one or two years' experience or at least summer vacation experience working in mines. Bulk of mining is open-pit work with shovels, draglines, bulldozers, trucks, etc. Milling operations include both wet and dry operations. Machinery used includes coarse and fine crushing machinery, jigs, ball mills and Raymond mills; vibrating screeens, classifiers, dewaters and thickeners, centrifuges and flotation machines, etc. Starting salary, $3900 a year. Location, one for Arkansas and the other for Missouri. Y7888.

General Manager with technical education and experience and executive ability to assume complete responsibility in operating a plant doing stripping, mining, hauling, milling, drilling and delivery of manganese ore. Location, Arkansas. Y8066.

Mining Consultant with at least ten years' coal mining experience for examination and evaluation of strip and underground project. Temporary. Salary open on a per diem basis. Location, Korea. Y8201.

Engineers. (a) General Superintendent, under 50, with underground iron ore mining experience. Salary, $10,000 to $12,000 a year. (b) Mine Foreman, young, to take charge of shift operations. Location, eastern United States. Y8260.

Mining Engineer, E. M.; must have had four or more years' experience in quarrying hard rock, rushing and servicing and possibly some underground background. Knowledge of Geology. Will be in charge of general engineering having to do with quarrying, crushing and screening of rock and rock products. Company manufactures building materials. Salary up to $500 per month. Company will negotiate fee. Location, Chicago, Illinois. R9630(b).

Assistant Manager, 40 to 45, mining or mechanical graduate, with at least ten years' mining and dredging, plant maintenance and managerial experience. Must speak Spanish. Salary, $12,000 a year. Location, Latin America. Y8295.

Engineers. (a) Assistant Manager, 35 to 45, experienced in underground mining operations, mechanized mining. Salary, about $15,000 a year. (b) Chief Engineer, 35 to 45, experienced in design of surface mining structures, mine surveying. Salary, about $12,000 a year. (c) Mine Foreman, 30 to 40, experienced in underground, square set, cut and fill stopes, to take charge of setting up mine mechanization program. Salary, about $9000 a year. Positions are for expansion program and mechanization in underground metal mine. Location, Caribbean Area. Y8258.

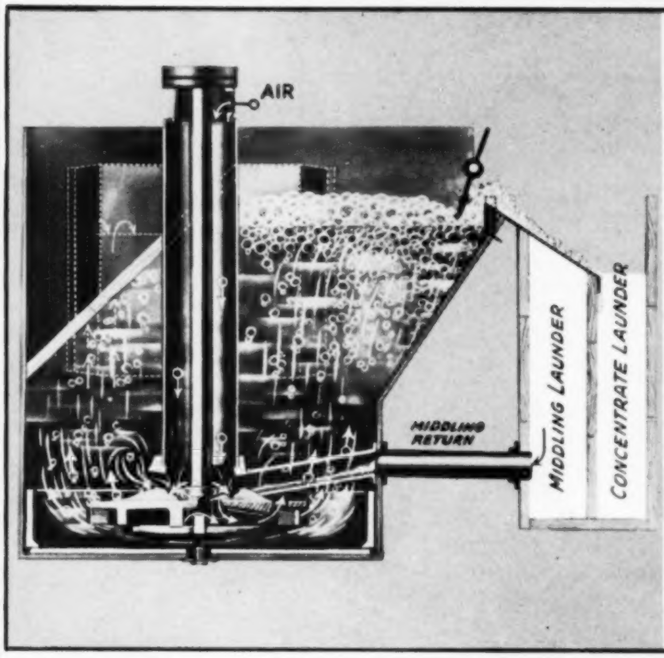
Mining Engineer, registered, with several years' experience in coal mining. Location, West Virginia. Y7935.

Assayer with nonferrous, secondary smelting experience. Salary, $4160 to $5200 a year. Location, northern New Jersey. Y8261.

Mining Engineer, young, graduate, with 1 to 2 years experience, for underground talc mine. Duties include sampling, surveying, mapping, making ore reserve calculations and similar activities. Salary, $4200 to $4500 a year. Location, upstate New York. Y8346.

DENVER "SUB-A" FLOTATION

Complete Milling Equipment — from testing, to feeder, to dryer!



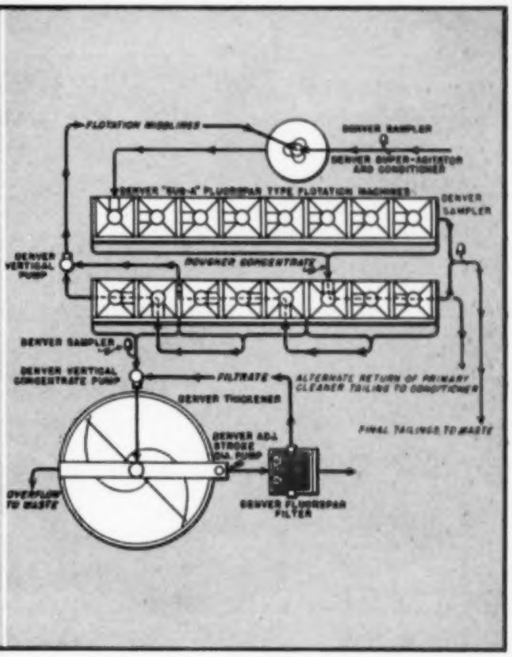


Photo at left shows cut-way view of Denver "Sub-A" Flotation Cell. Note how feed pipe enters at low level discharging on to impeller Flowsheet at right illustrates flexibility in returning froth products for additional cleaning without use of pumps or step-downs. Note complete control of cleaner-cell tailings as they are recirculated.

Exclusive Principle of Denver "Sub-A" Flotation Permits Gravity Return of Middlings and Froth Without Pumps or Step-Downs

Clean, high grade concentrates and much lower costs are made possible by Denver "Sub-A" Flotation Machines. With cells all on one level, you can return concentrates to cleaner cells by **gravity flow**, and recirculate cleaner tailings. This completely eliminates expensive pumps and step-downs. Only Denver "Sub-A" Flotation offers these exclusive features. Positive recirculation — without "short circuiting" — gives you lower tailing and highest grade concentrates.

GRAVITY RETURN

The high original costs and maintenance of pumping or stepped down cells are unnecessary when you use Denver "Sub-A" Flotation. This is because the feed pipe is located near the bottom of each Cell—directly over the impeller. Since the location of this feed pipe is low, it is a simple matter to return middling froth by gravity down a launder into a cleaner cell six to eight cells away. The low level of the feed pipe also makes it possible to recirculate tailings from cell to cell— without pumps.

Thus, in Denver "Sub-A" Flotation Machines, cell-to-cell gravity flow and cell-to-cell middlings return is easy. You thereby eliminate pumps and step downs...and get better metallurgy...and have the flexibility you need to meet changing conditions.

HIGHER GRADE CONCENTRATES

Another important feature in all Denver "Sub-A" Machines which allows you to get higher values is the positive circulation feature. Positive circulation means that all material entering a Denver "Sub-A" Cell must enter through the feed pipe directly over the impeller. Thus any feed, middling return, froth return or coarse sand product gets maximum exposure to flotation treatment. As a result, Denver "Sub-A" Flotation gives you lower tailings and higher grade concentrate.

Write or wire—find out about the many other advantages of Denver "Sub-A" Flotation which help you get greatest profits with lowest costs.

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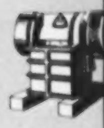
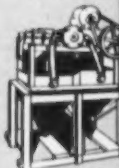
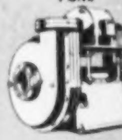
DENVER DISC FILTER


DENVER JAW CRUSHER


DENVER STEEL HEAD BALL MILL


DENVER MINERAL JIG

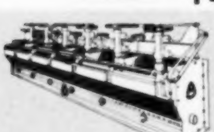

DENVER VERTICAL PUMP

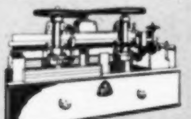

DENVER SRL PUMP


DENVER AUTOMATIC SAMPLER


DENVER STEEL HEAD ROD MILL


DENVER ORE FEEDER


DENVER "SUB-A" FLOTATION

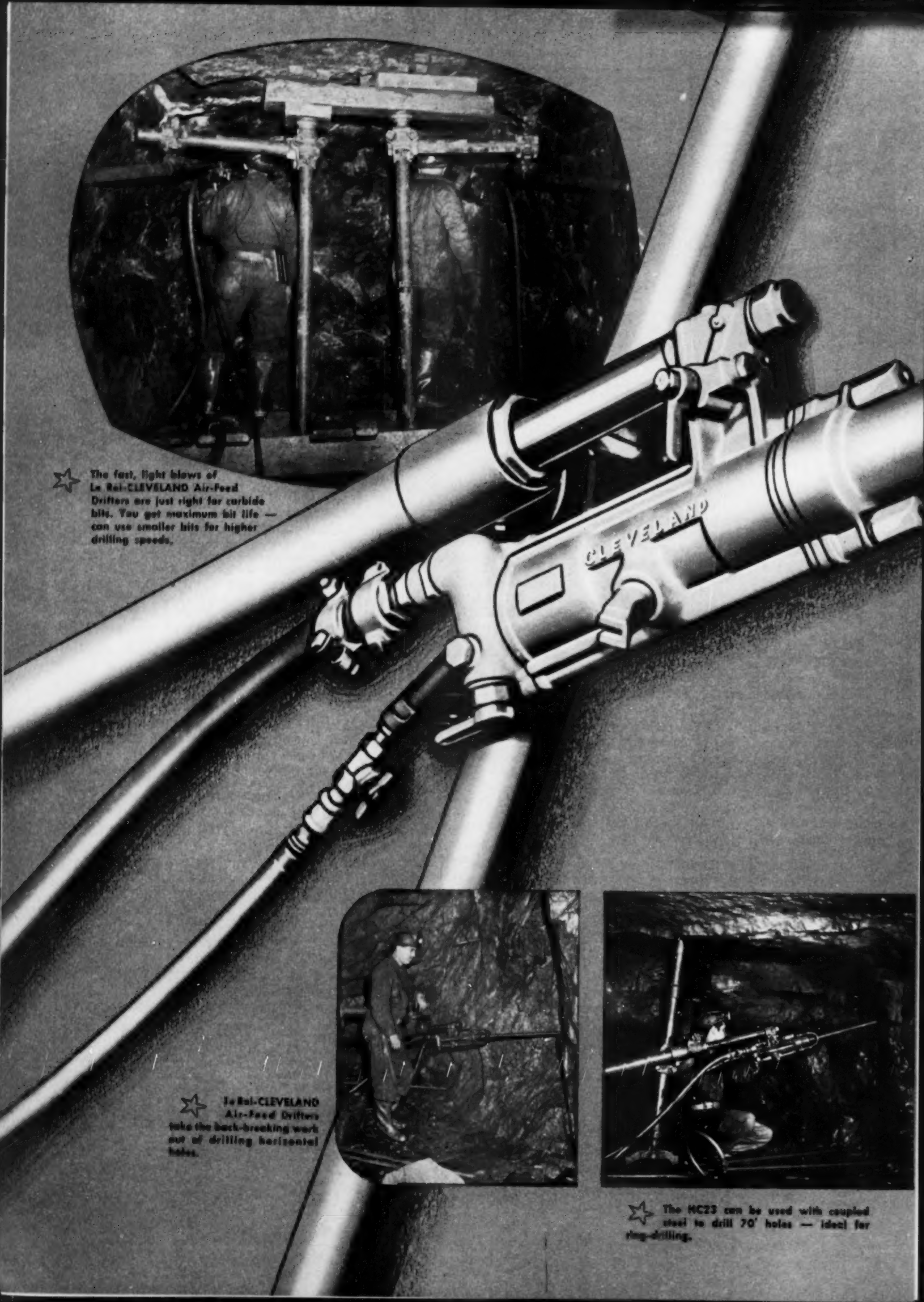

DENVER "SUB-A" SUPER ROUGHER FLOTATION MACHINE


DENVER SUPER AGITATOR AND CONDITIONER


DENVER "SUB-A" UNIT CELL


DENVER DIAPHRAGM PUMPS


DENVER DILLON SCREEN



The fast, light blows of Le Roi-CLEVELAND Air-Feed Drifters are just right for carbide bits. You get maximum bit life — can use smaller bits for higher drilling speeds.

Le Roi-CLEVELAND Air-Feed Drifters take the back-breaking work out of drilling horizontal holes.

The HC23 can be used with coupled steel to drill 70′ holes — ideal for ring-drilling.

Meet The Authors

F. R. MORRAL

F. R. Morral (p. 383) is a graduate of Massachusetts Institute of Technology (B.S. in 1932) and Purdue University (Ph.D. in 1940). Dr. Morral was in Sweden and Spain for several years prior to joining the Continental Steel Corp. as research metallurgist in 1930. He joined the staff of Pennsylvania State College in 1941 and was assistant professor of metallurgy. He was associated with the Mellon Institute and in 1944 became connected with the American Cyanamid Co. as group leader in the metals trades laboratory. Prior to joining Kaiser Aluminum & Chemical Corp. as head of the X-ray diffraction dept., he was associate professor of materials engineering at Syracuse University. Dr. Morral is a member of the AIME, Columbia Section; Iron and Steel Institute, England; Institute for Metals, England; American Crystallographic Society; ASM; Wire Assn.; American Society of Engineering Education; and Instituto del Hierro y del Arcero (Madrid).

RAMACHANDRA RAO

Ramachandra Rao (p. 400) of the Geological Survey of India has worked for several companies in India. He presently resides in Calcutta. Mr. Rao has published geology papers in his native country and is a member of the AIME. He has also authored two papers for transactions volumes of the Institute. He is a graduate of Central College, Bangalore, India, holding a Master of Science in Geology from the University of Mysore. While at school he played football, volleyball and badminton.

Henry F. Hebley (p. 404) is a research consultant for the Pittsburgh Consolidation Coal Co., Inc. During World War II he served the Board of Economic Warfare in Australia. Following the war he was a member of the commission sent to Poland and the Ruhr representing the International Bank for Reconstruction and Development. Born in New Zealand, Mr. Hebley was educated at Christ Church Technical College. In the U. S. he had been employed by Marshall and Stevens, United Verde Copper Co., and several other companies before going to Pittsburgh Consolidation.

CLARENCE R. KING

Clarence R. King (p. 375), presently a consulting engineer, was mill superintendent, California Rand Silver Inc. when zanthate was introduced by Minerals Separation. He later worked for Yeatman and Berry. He was also employed in research and mine valuation with United Verde Copper Co. He has been vice president and manager of Cia Mra. Guazapares, and president of Cia Mra. Sta. Elena, Mexico, Mr. King is interested in ore dressing research and bee-keeping, in addition to home construction. A member of the AIME, he has written papers on optical calcite in Mexico, soda ash, perlite, mercury, and other minerals. He is a graduate of College of Mines, University of California.

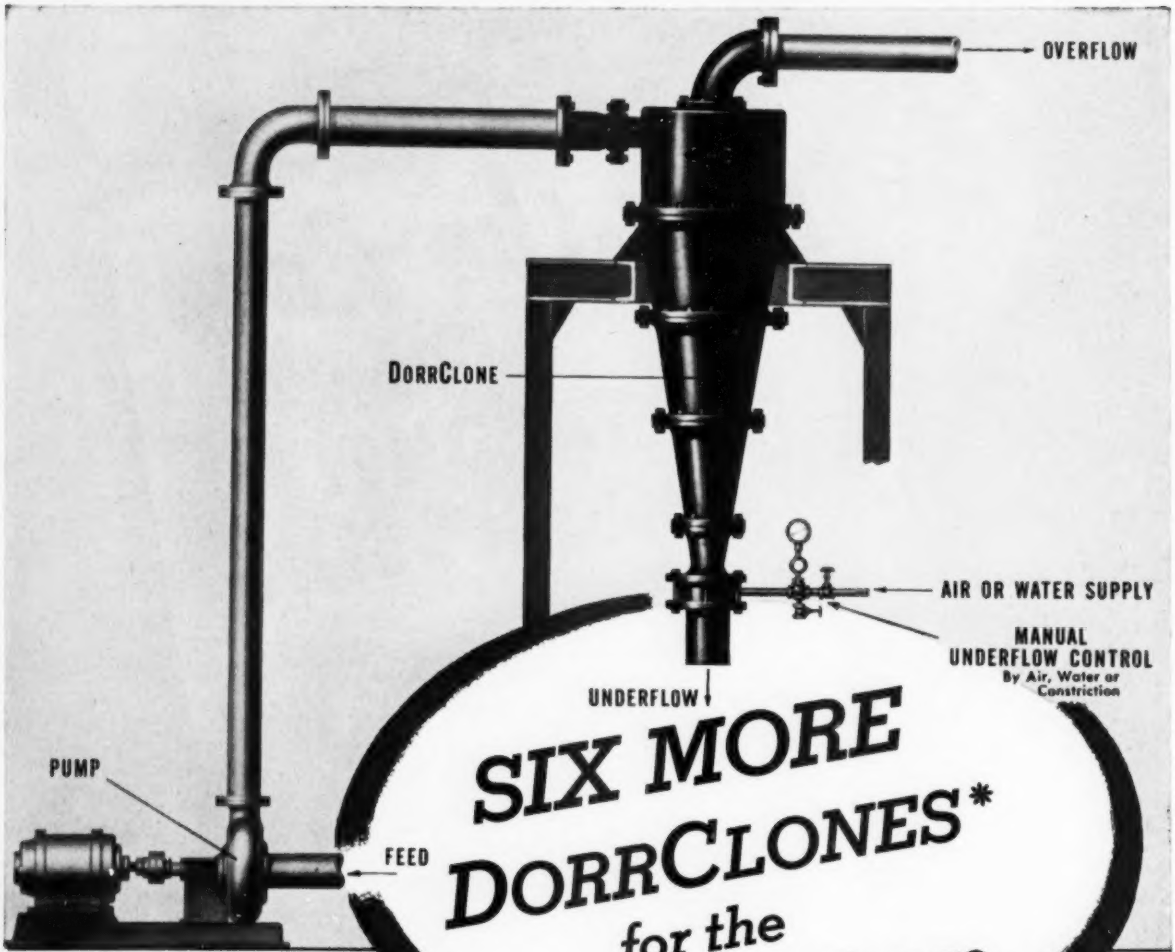
E. A. Jones (p. 387) has been with St. Joseph Lead Co. for more than 26 years, starting as a mine surveyor, graduating to mine captain, and then to his present position of division manager. A graduate of the University of Minnesota, Mr. Jones was a member of Sigma Alpha Epsilon and Theta Tau while at school. His first job after graduation was at Ducktown, Tenn., as a mine surveyor. He is now a resident of Bonne Terre, Mo., and a member of the school board and the Rotary Club. One other paper, Development with Trackless Equipment, was presented before the AIME to the Columbus, Ohio, section, September 1948. Mr. Jones spends much of his spare time at his hobby, gardening, with emphasis on flowers he says.

MERLYN B. BUHLE

Merlyn R. Buhle (p. 395), associate geologist with the Illinois State Geological Survey Div., is a graduate of the State University of Iowa, holding a Bachelor of Science and Master of Science degree. He has been employed by Layne-New York Co., in electrical earth resistivity surveying, American Geophysical of Baltimore, and Illinois State Geological Survey since 1938. He has authored papers for the Illinois Academy of Science and was co-author of an article in Economic Geology in 1951. His two daughters and an eight-year-old son take up most of his free time. As a family, they swim and travel throughout the U. S. Mr. Buhle is also a breeder of champion pigmy pouter pigeons and president of the Citizens Civic Committee and Deacon of the First Congregational Church.

PAUL W. ALLEN

Paul W. Allen (p. 379) is currently plant manager of National Lead Co.'s MacIntyre development at Tahawas, N. Y. Born in Chambersburg, Pa., Mr. Allen graduated from MIT with a Bachelor of Science in Mining Engineering. He has worked for Inland Steel Co., at the firm's Ishpeming, Mich., iron mining department as chief engineer; Cyprus Mines Corp., as a mining engineer; and as assistant mine superintendent at the MacIntyre development. Mr. Allen is the author of a previous article which appeared in the November 1943 issue of *Mining and Metallurgy*. Main interest outside of his work, according to Mr. Allen, is skiing.



SIX MORE DORRCLONES* for the Iron Range

PROBLEM — *To make a 200 mesh separation on a high-solids content iron ore . . . without prior dilution.*

RESULT — *Extensive test work on a 24" dia. DorrClone resulting in an order for six additional 24" units.*

At Cleveland Cliffs Iron Company's Canisteo Washer, a 24" dia. DorrClone was installed on a test basis to determine the desirability of desliming their classifier overflow prior to conventional fine ore treatment. Standard hydroseparation was impossible without considerable dilution as these overflows contained a high percentage of solids.

The DorrClone was required to make a satisfactory size separation on feeds varying widely in both percent solids and structure. During the tests, solids varied from 17-35% and +200 mesh in feed varied from 25-35%. The Beneficiation Engineer at Canisteo reported that "after initial adjustments, these variations seemed to have little effect on the operation . . . the DorrClone operated very satisfactorily."

If you have a desliming problem, there's a good chance that the DorrClone, with its high capacity-for-size and ability to handle flocculant or heavy pulps, will be the solution. For further information write for bulletin No. 2500. The Dorr Company, Stamford, Conn.

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Letters to The Editor

Mining Laws

The item concerning the mining laws which appeared in the "Trends" feature of the January, 1953 issue has been a severe surprise. The campaign for revision of the mining laws, of which the "Trends" note is an unwitting part, has been of long standing and of a vicious and underhanded nature. The campaign is gaining impetus of late with the help of "a few well-meaning but misinformed organizations and individuals." Let's keep the A.I.M.E. out of that latter category by checking the facts of the case before publishing the bureaucrat's propaganda for them.

Although I have not read the specific article described, the title suggests that it is one of the series written by an author whose only claim to knowledge of the mining laws has been gained by taking tours guided by Bureau of Land Management and Forest Service officials. It is very doubtful that the man has studied the law because of the glib way that he throws dubious facts and half-truths around as though they were the gospel.

I defy any man to obtain a claim, in or out of a national forest (without the tacit help of the bureaucrats), for the purpose of building a summer home, a hunting lodge, or for the purpose of removing timber by the simple means outlined in the various propaganda articles that have been published.

The articles do sound logical to those who are not well acquainted with our mining laws, or with the facts in the case. However, court records are full of successfully prosecuted cases covering mining claim violations of all kinds.

The law specifically states the rules by which the prospector must operate in order to hold his claim. It also gives the Bureau of Land Management and the U. S. Forest Service the authority to enforce the rules. Until recent years, these organizations have administered the laws conscientiously and well by using the very laws they now attack so vigorously.

Their present policy appears to be one of non-enforcement seemingly in an effort to encourage violations for use in propaganda to force revision. While some revision of the law may be of some benefit to all concerned, I do not, and I am sure that others will agree, want revision along the lines outlined by the government bureaus.

These bureau sponsored revisions would effectively cut the domestic mining industry off at the roots by making it nearly impossible for the small prospector to hold and develop a claim. Contrary to popular belief, the small prospector is still an important member of the ore-finding team.

Our present law guarantees the prospector protection while developing his claim and, if he has followed the specific rules set forth in the law, has done the required amount of work, invested the proper amount of money, and can get the bureaucrats to leave their propaganda campaign long enough to process his papers, he can then buy the land from the government. If on the other hand, he has not complied with the rules (any one of the provisions of the law), he is liable to adverse proceedings and the possible loss of his claim.

The law does give the prospector his day in court, but he must prove that he has complied with the provisions of the law in intent and in fact.

The revisions proposed by the bureaus would make it more simple

to dispossess any claimant by "administrative decision not subject to court review."

It might also be well to consider the effect of like revision of our criminal laws.

In closing, I would like to point out the fact that our mining laws were designed by miners for the use of miners. They have stood the test of time, and have grown by reason of tests in the courts, where decisions on all types of violations have served to plug the loopholes that may have originally existed. They protect the miner and prospector and set forth the mechanism for the prosecution of violators. *Conscientious enforcement* will benefit more people than will revision.

I strongly recommend contacting any of the officials of the various mining organizations in the public land states, or the American Mining Congress, before pushing the issue further.

There is a confidence game involved in the issue, but it appears to be worked more by those organizations charged with the enforcement of the law than by the violators they encourage by their published cries of feigned helplessness.

E. O. Bracken
Kellogg, Idaho

The item in question, (Trends, p. 32, January Mining Engineering*) brought out the point that organizations far from mining have the feeling that they are concerned.—Editor*

Correction

On page 152, February issue Mining Engineering, it is stated the "William M. Barret, Inc. . . . reports that the discovery of the Indian Creek orebody in Missouri in 1951 followed Radore exploration."

Actually, the Indian Creek orebody was discovered by wildcat exploration, based on geological premises, in 1947-50. The known ore was used as a means of testing the Radore method in 1951. Indications obtained in this trial did suggest the possibility of a minor extension, which was confirmed by subsequent drilling.

John S. Brown,
Chief Geologist
St. Joseph Lead Co.

Largest Submarine Mine?

Dominion Steel & Coal Corp., through one of its subsidiaries, Dominion Wabana Ore Ltd., carries on submarine mining of iron ore at Wabana, Bell Island in Conception Bay, Newfoundland. The areas worked out now extend as far as 2½ miles from shore and recently there has been installed a rubber belt conveyor, claimed by the suppliers to be the longest rubber belt conveyor system of its type in the world.

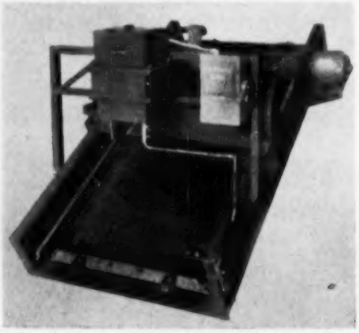
It has been suggested to us that we are the largest, if not the only people in the world who conduct submarine iron ore mining operations, at any rate there are some seventeen hundred men employed under the ocean at Wabana and their efforts are expected shortly to result in the production of some ten to twelve thousand tons of iron ore per day.

Can you help inform us whether we are the only submarine iron ore mining operation in the world, the largest undertaking of that kind or what our standing is?

L. J. Doucet,
Industrial Relations Dept.

Screen

Latest model of *Deister Concentrator Co.'s* Leahy NO-Blind, heavy duty, vibrating screen features a more rigid aluminum suspension bar. Changed suspension results in improved screen cloth action, easier



adjustment of screen cloth tensioning. Photograph shows latest model of 4x7-ft Leahy screen equipped with FlexEiex equipment for heating the screen jacket. FlexElex equipment may be ordered for new screens from the factory, and is available in conversion sets for older Leahy units. **Circle No. 1**

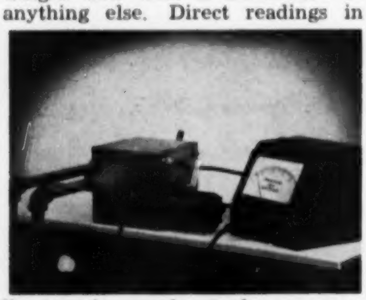
High-Pressure Hose

Republic Div. of *Lee Rubber & Tire Corp.* is producing Wiretex; flexible, high-pressure industrial hose which is claimed to withstand flexing and vibration and does not

rust or corrode. Available in sizes from 3/16 to 2 in., it is suitable for uses up to 5500 psi and high temperature requirements. **Circle No. 2**

Flowmeter

Control Engineering Corp. has developed a flowmeter to measure weight flow that is insensitive to anything else. Direct readings in



lb-per-min can be made on gases, liquids, or slurries, with accuracy independent of volume, temperature or other factors. **Circle No. 3**

Ball-Rod Mill

Denver Equipment Co.'s 30 in. diam Convertible Ball-Rod mill has been improved for convenience in modification and to facilitate repairs. The unit is adaptable to lengths up to 72 in. Trunnion in discharge end is large enough for a man to enter, makes liner replacement easy. Type of discharge opening may be changed by merely installing correct throat liner; grate liners may also be installed. **Circle No. 4**

Crawler Lugs

Claimed to give rubber tired tractors increased pulling power in mud, snow, and sand; *Comco* Vise-

Grip retractable lugs can be retracted or extended in 4 min., can be installed in an hour. **Circle No. 5**

Safety Switch

Availability of 200-a, 600-v front-operated HCI switch has been announced by G.E.'s *Trumbull Elec-*

tric Dept. Outstanding characteristic of the line of 30, 60, 100 and 200-a switches is high capacity interruption. **Circle No. 6**

Steel Tapes

New, popular priced chrome plated steel tapes in 25, 50, 75, and 100-ft lengths, are offered by *J. Roe & Sons Inc.* Chrome plating creates blue-white background for legible markings. **Circle No. 7**

Electronic Tool

Portable electronic stethoscope made by *Anco Instruments* aids maintenance men in locating friction noises in bearings, gears, and other parts. **Circle No. 8**

Jaw Crusher

Pioneer Engineering Works Inc. has added a 42x48-in. overhead eccentric jaw crusher to its line. Weighing over 94,000 lb the new crusher is equipped with SKF self-aligning roller bearings to conserve power and reduce shaft strain. Gape is adjustable from 4 to 13 in., crushing chamber capacity is over 4 cu yd. All-welded base is built in two halves to facilitate handling with standard equipment. **Circle No. 9**

Engines

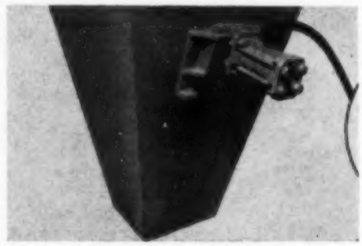
A first for the industry was claimed by *Briggs & Stratton Corp.* when its 1952 production reached 1 million engines. **Circle No. 10**

Portable Winch

Lightweight portable electric or gasoline powered winch announced by *Stampco Products* is designed for multi-purpose use, and built in sizes ¾ to 7½ hp. **Circle No. 11**

Vibrator

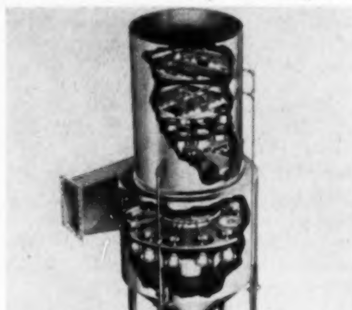
Cleveland Vibrator Co. announced development of a new 2-in. piston air vibrator. Major feature of new



unit is quick, easy portability. It is suitable where one vibrator can serve several bins. **Circle No. 12**

Scrubber

Liquid precipitator multiple-action scrubber produced by the *Johnson-March Corp.* has system



combining six different principles of dust precipitation; is built in sizes for 1500 to 48,000 cfm. **Circle No. 13**

WORLD'S LARGEST TRUCK built by Dart for Bagdad Copper Mines is a strictly off-the-highway job. Twin diesels mounted under the body supply 700 hp through fluid drive to power the 60-tonner. Front suspension floats on air, is steered by hydraulic arms mounted on either side of the axle. For more information circle No. 14.

Magnetic Pulley

What is believed to be the biggest Alnico magnet pulley ever built—36 in. diam, 36 in. belt width—has been made by *Dings Magnetic Separator Co.* **Circle No. 15**

Varidrive Motors

The horizontal assembly line of Varidrive motors built by *U. S. Electrical Motors Inc.* now includes a 30 hp size. **Circle No. 16**

Free Literature

(17) TORQUE CONVERTERS: Inside story of *General Motors* Torque Converter, integral part of many GM engine models has been published by the Detroit Diesel Engine Div. in a well illustrated book with cutaway drawings, horsepower curves and photos of applications.

(18) DIAMOND DRILLS: New general bulletin by *E. J. Longyear Co.* shows Straitline diamond drills, and drilling supplies. Also illustrated is the Arvela precision magnetometer, claimed to reduce survey time without sacrifice of accuracy.

(19) BULLDOZER: *Baker Mfg. Co.* bulletin describes their "no-push-beam, highway width" bulldozer with Baker blade on frame of *Allis-Chalmers* HD-15 tractor.

(20) BUILDINGS: A 6-page booklet issued by *Armco Drainage & Metal Products Co.* describes its patented steel panel buildings.

(21) GRINDING MILLS: *Hardinge Co.* has issued a new circular describing the complete line of Hardinge conical, rod, cylindrical, tube, batch, and Tricone mills and the Thermomill.

(22) TUBE MILLS: A 12-page catalog recently released by *Hardinge Co.* discusses application, construction and specifications for Pebble Tube mill and the Ball Tube mill, and illustrates several types of compartment mills.

(23) HOIST PHONE: Frequency-modulated carrier communication for mine hoists is covered in a circular from *Mine Safety Appliances Co.* Called HoistPhone, the new system is designed to maintain two-way conversation between hoisting engineer and the cage, at any level or while cage is in motion.

(24) HARDSURFACING: "Hardsurfacing Comparison Chart" issued by *Rankin Mfg. Co.* lists leading manufacturers of hardsurfacing rods, and the specific rod for various uses.

(25) PUMPS: An 8-page bulletin from *Western Machinery Co.* shows construction, design and operation of Wemco sand pumps, as well as giving necessary data for selecting proper pump size.

(26) PULVERIZING: "The New Art in Industrial Pulverizing," on pulverization of materials such as limestone, coal, feldspar, and graphite was published by *Majac Eng. Co.*

(27) PUMPS: *Allis-Chalmers* close-coupled pumps are described in a new folder. Units are available in capacities to 2500 gpm at heads to 550 ft and feature minimum space requirement.

(28) AMSCO PRODUCTS: Manganese steel products to help mining industry "fight high cost of wear" are topic of booklet from *American Manganese Steel Div.* of American Brake Shoe Co.

(29) GEAR DRIVES: *Link-Belt Co.* has issued a catalog on helical gear drives showing internal construction and giving design details.

(30) DECO EQUIPMENT: Of particular importance to executives interested in development and research is a 12-page illustrated bulletin explaining *Denver Equipment Co.'s* extensive testing laboratories and the work they can do.

(31) SHAFT MUCKER: A $\frac{1}{2}$-cu yd Hydromucker was announced by *Bucyrus-Erie Co.* New mucker carries features of $\frac{3}{8}$ yd predecessor in

addition to larger capacity clamshell. The 2025-lb bucket has alloy steel lips and teeth, is closed by two single acting hydraulic rams mounted horizontally within the bucket yoke. Bucket is claimed to bite down into muck, not draw away.

(32) FLOW METERS: Specification sheets in consolidated style covering the complete *Minneapolis-Honeywell Regulator Co.* flow meter line are now available.

(33) BULLDOZERS: Their booklet, "Bulldozer Line" is called "an encyclopedia on bulldozers" by the *Caterpillar Tractor Co.* Every size and style of bulldozer, and all attachments are shown in cutaway and model views.

Mining Engineering **April**
29 West 39th St.
New York 18, N. Y.

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Towering as high as eight feet on his hind legs, the Kodiak or Alaskan Brown Bear ranks as the most powerful animal of North America. Rugged muscle development makes him the feared and deadly fighter that he is.

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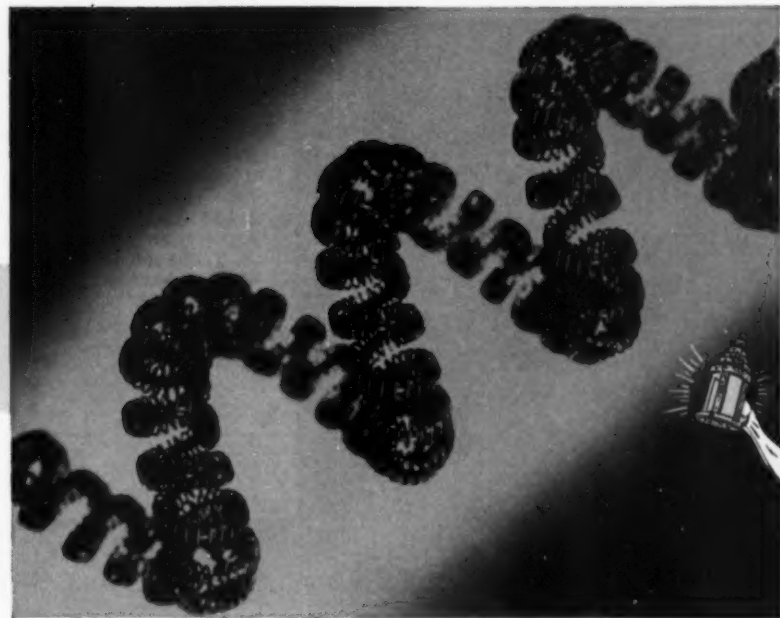
A YELLOW TRIANGLE ON THE REEL IDENTIFIES WICKWIRE ROPE

WICKWIRE ROPE

CF&I PRODUCT OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION



Shown at the left is a view of the triple-coil tungsten wire used in many modern fluorescent lamps. (Photo courtesy General Electric Lamps)

The "ARISTOCRAT OF RARE METALS" might have helped Diogenes . . .

If *TUNGSTEN*, the *"aristocrat of rare metals"*, had been discovered in his time, the Greek Cynic, *Diogenes* might have been able to carry a much brighter lamp to aid in his search for an honest man. For among the many contributions of this metal to modern civilization is the tungsten filament which gives a quality of artificial light otherwise unattainable.

Due to low grade characteristics, and the hard abrasive rock in which tungsten ore is generally found, producers must attain desired particle size for maximum recovery as quickly and economically as possible. It is significant to note the use of SYMONS® Cone Crushers by many of the large tungsten producers . . . who find these crushers particularly suited to tungsten ore reduction because of maximum utilization of crushing surfaces against the highly abrasive material, with minimum wear.

Thus, in tungsten operations . . . *as in all of the great ore and industrial mineral operations the world over* . . . SYMONS Cone Crushers are relied upon to efficiently produce great quantities of finely crushed product at low cost.

NORDBERG MFG. CO., Milwaukee, Wisconsin

SYMONS Cone Crushers...*the machines that revolutionized crushing practice*.. are built in Standard, Short Head, and Intermediate types, with crushing heads from 22 inches to 7 feet in diameter—in capacities from 6 to 900 tons per hour.

SYMONS . . . A REGISTERED NORDBERG TRADEMARK KNOWN THROUGHOUT THE WORLD.

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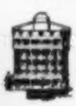
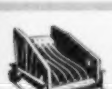


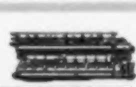
SYMONS PRIMARY CRUSHERS

GRINDING MILLS

MINE HOISTS



SYMONS VIBRATING BAR GRIZZLIES and SCREENS



DIESEL ENGINES

Rep. William S. Hill (R.- Colo.) will preside over a Congressional hearing investigating the problems of the mining industry to be conducted in Phoenix, Ariz., late in April. Rep. Hill has expressed the desire to hear from the industry itself all possible testimony on the needs of domestic mining and how Congress can help. Rep. John J. Rhodes of Arizona is also expected to attend the hearing.

Two new features are incorporated into an SO_2 process for treatment of low grade manganese ores disclosed by Chemical Construction Corp. The new approach includes a high temperature autoclaving step and a sintering operation. Data was given for work performed on Cuyuna Range ores.

National Lead Co. will operate its Texas Mining & Smelting div., as part of the firm's metal department. The division, with offices in Laredo, Texas, has antimony mines in Mexico. Ore processing is in Laredo.

Special research on germanium will be carried out at a laboratory to be established by Newmont Exploration Co., in Grass Valley, Calif. A portion of the Empire-Star Mines Co. laboratory has been leased for research on ores from Tsumeb, South Africa.

Tentative plans for reopening its Yellow Pine antimony smelter at Stibnite, Idaho with a production schedule of 25 pct of capacity were announced by Bradley Mining Co. Reopening will depend upon market conditions. The smelter has been closed since last fall.

McCreary County, Ky., suffered another paralyzing blow to its economy with the announcement that two Stearns Coal & Lumber Co., mines will be closed. Mine 4 and Mine 18 will close while Mine 16 continues operation. A total of 270 men were employed in the closed coal operations. Mine 4 operated 49 years.

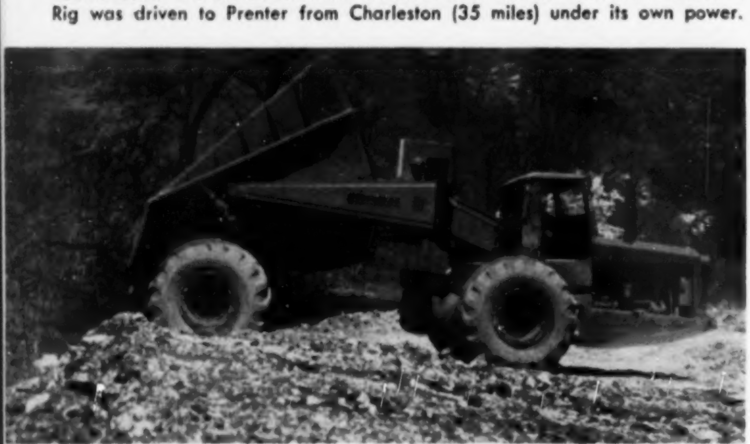
Belgian Congo copper will come to the U. S. for sale for the first time in about 20 years. The copper will come from the Union Miniere du Haut Katanga, one of the four top producers in the world. Shipments are expected to start in April. Cause of the new offers is the reported falling off of the European market.

American Sulphur & Refining Co., is building its first commercial plant near Fillmore, Calif. The company was formed about one and half years ago to "develop a process for the extraction of elemental sulphur from native volcanic sulphur-bearing ores." Production is scheduled to start in about five months with an output of about 100 tons of 99.5 pct quality sulphur.

Eight months of experimental testing of a coal pipeline proved the project economically feasible according to George H. Love, president of Pittsburgh-Consolidation Coal Co. The firm announced that it will go ahead with development of commercial aspects of providing sales outlets. Experiments were carried on near Cadiz, Ohio.

240 tons hourly at Red Parrot Mine

Tournarocker is chute-loaded with 15 tons of slate and bone coal in 18 seconds. Rig was driven to Prenter from Charleston (35 miles) under its own power.



Arriving at dump, Tournarocker backs to edge of bank. Big 4-wheel air brakes, plus front-wheel drive, give operator confidence for fast dumping, maneuvering.

1 "C" Tournarocker

Coal miners today are working many seams never before considered practical — thanks to new techniques in drift-mining and refuse-removal. Take the two Red Parrot Coal Company seams near Prenter, West Virginia, for example. Here's how they operate:

Red Parrot (division of North American Coal & Dock Corp., Cleveland, Ohio) removes coal from the mine in $2\frac{1}{2}$-ton cars . . . dumps it into a "rope and button" conveyor running to the tipple and washer. Refuse — mostly slate and bone coal — is conveyed to an overhead bin several hundred feet above the plant. Then . . . to complete the company's time-saving, labor-saving mechanization . . . Red Parrot hauls refuse from bin to dump with a C Tournarocker. Production records show this *one* 18-ton Rear-Dump does the work of *three* 6 to 8-ton dump trucks on the refuse-removal operation.

16 loads per hr. on 3000′ cycle

Working 2 shifts a day regardless of weather, Tournarocker is chute-loaded at the bin with

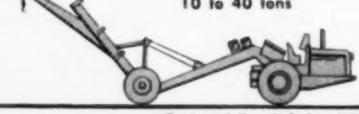
INTERCHANGEABLE FOR EXTRA PROFITS

Same prime-mover is readily interchanged for use with scraper, bottom-dump, flat-bed, or crane. Assures year-round profits.

TOURNAPULL* SCRAPER
7 to 42 yds.

BOTTOM-DUMP TOURNAHOPPER*
18 and 27-yd.

MOBILE TOURNACRANE*
10 to 40 tons



*Trademark Reg. U.S. Pat. Off.

Tournarocker speeds from conveyor bin to dump in 3rd gear with full load of refuse. After 2,000 hours operation, owners report 98% mechanical efficiency.

does work of 3 trucks

15 tons of slate and bone coal in an average of 18 seconds. It hauls 1500′ to the dump in 1 minute 24 seconds . . . dumps in 6 seconds . . . and returns to the bin in 1 minute 20 seconds, for an average speed of 12.6 m.p.h. Rig completes the 3000′ round trip in 3 minutes 6 seconds . . . makes 16 trips per 50-minute hour. Hourly production averages 240 tons. No wonder Outside Superintendent F. Mason Morgan says, "We are well pleased. Tournarocker works better than any rubber-tired equipment we've used." He adds, "Operator efficiency is up, too."

Rocker body tips to vertical, dumps instantly, clear over bank. Requires less clean-up, reduces cycle time. Rig's simple, sturdy design (no frame, no subframe, no springs, no hydraulics) saves on maintenance, too.

Get facts for your work

Whenever you have rock, ore, or shovel-dirt to move, your best bet is Tournarocker. Available in sizes from 9 to 50 tons, 122 to 450 h.p. Constant-mesh transmission, torque converter, electric body heating unit, are optional. See your LeTourneau Distributor for factual job reports on work like yours. Let him arrange to show you rear-dump Tournarockers at work in your area.

Tournarocker—Trademark Reg. U. S. Pat. Off. R-218-CM-w

TOURNADOZER* BULLETIN gives all facts about 19 mph rubber-tired tractor that runs instead of crawls. Job-proved 186 hp unit strips overburden, maintains haul roads, cleans for shovel. Twice as fast as crawlers. Write for your free copy of book.

R. G. LeTOURNEAU, INC.
Peoria, Illinois

U. S. Signs Pact With Miami Copper

Miami Copper Co., of Arizona has agreed to mine lowgrade copper ores in an extension of its Globe-Miami mining district operations at a guaranteed price of 27.35¢ per lb, under a contract signed with defense Materials Procurement Agency.

Terms of the contract call for delivery of 230 million lb of refined copper between 1955 and 1962. DMPA said highgrade ore in the deposit will soon be exhausted and it is considered advisable to have Miami continue the operation. The Government has an option to buy 120 million lb of refined copper from present production at market prices.

Miami will develop the new orebody at its own expense—estimated at $3 million. If losses under the new contract reach a specified point, Miami may cancel the agreement. The company plans to use the block caving method in the underground operation.

Steel Co. of Canada Buys into Erie Mining

Youngstown Sheet & Tube Co., sold a 10 pct interest in the Erie Mining Co. to the Steel Co., of Canada, but still retains a 35 pct share of the firm.

Erie is planning a large taconite development project on the Mesabi Range. Erie management is under Pickands Mather & Co., Cleveland. Interlake Iron Corp., interest in Erie has increased to 10 pct. Bethlehem Steel Corp. is holder of a 45 pct interest in Erie.

Eureka Mining Studies Production Problems

A consulting firm will make engineering studies of the Eureka Mining Co., lode gold mine at Sutter Creek, Calif., during a 90 day shutdown to determine ways to increase ore output from slightly more than 200 tons per day to 350 tons per day.

About 60 miners and muckers were laid off but approximately 90 maintenance, hoist, shaft, and pump men, as well as supervisors will remain on the job.

Idaho Maryland Mines Corp., of Grass Valley, another Mother Lode mine, reported an unprofitable year in 1952. The firm reported a loss of about $59,000 in 1952 before depletion and depreciation charges, which ran about $180,000 in 1951.

A Tri-state lead-zinc operator has moved a P&H shovel underground to gather operating data on this type of machine as an underground loader. With the prevailing prices of lead and zinc, low maintenance costs and high production are features any machine must have to survive in this district.

AS&R to Develop Peruvian Copper Mine With Proven Reserves of 400 Million Tons

American Smelting and Refining Co. announced that it will soon begin development of the Toquepala copper deposit in southern Peru, 10,000 ft above sea level in the Andes Mountains.

Drilling at the Toquepala property last year disclosed proven ore reserves in excess of 400 million tons assaying at slightly more than 1 pct copper per ton of ore. Mining will be by open pit. Approximately 92 million tons of overburden will have to be removed in preparation for mining at an estimated 22,000 tons of ore per day.

AS&R has another property some 14 air miles distant at Quellaveco, but mining at this property is not contemplated for a number of years. Drilling, completed in 1950, disclosed a deposit containing about 200 million tons of copper ore assaying at less than 1 pct copper to the ton.

Toquepala is about 56 miles northeast of the Peruvian port of Ilo, but construction of a 100 to 110 mile railroad will be necessary. First estimates peg the cost of bringing the mine into production at about $160 million, including mine preparation, equipment, concentrator, water supply, railroad, smelter, power plant, port works, town sites, and working capital.

Production for the first 10 years is estimated at 100,000 tons of blister copper annually, and 85,000 tons a year for the following 20 years. The remaining period of the estimated 20 year life for mine is expected to produce 68,000 tons annually.

A loan application has been made to the Export-Import Bank on behalf of the newly organized and wholly owned Southern Peru Copper Co., which will operate both properties. The balance of funds will be supplied by AS&R.

Uranium Mine Bonus Payments $1,459,126

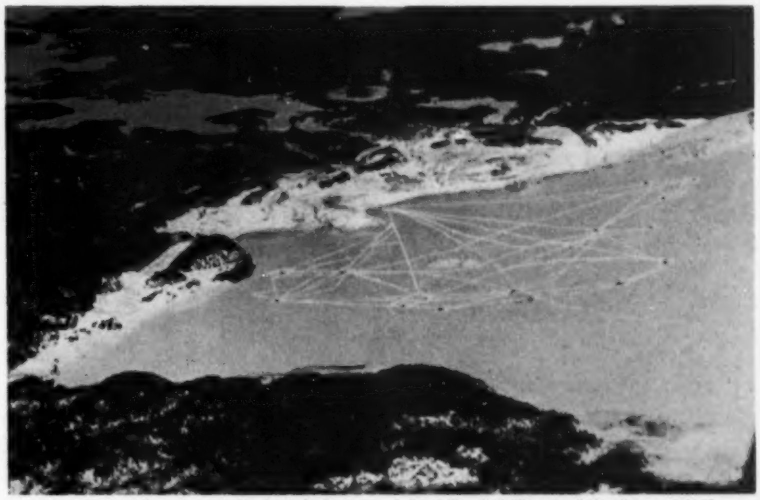
Atomic Energy Commission reports that uranium miners have received $1,459,126 in bonuses for initial production between Mar. 1, 1951, and Feb. 20 this year.

Bonus payments "to encourage and assist the development of new sources of domestic uranium production" are now being made at a rate in excess of $200,000 per month. Payments are made to producers on the part of the first 10,000 lb of uranium oxide in acceptable ore delivered to qualified mills or ore buying stations between Mar. 1, 1951 and Feb. 28, 1954. Bonus payments apply to new mines or mines which did not deliver 10,000 lb of uranium oxide before Mar. 1, 1951.


the
GARDNER-DENVER
way

Inland Steel Leases "C" Orebody at Steep Rock

$50 Million Project To Produce Three Million Tons Per Year



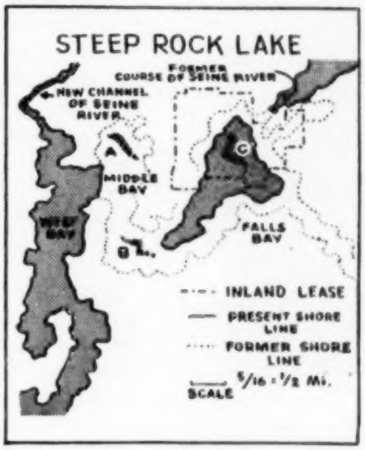
Aerial view shows network of roads between Inland Steel drill rigs. Inland is continuing exploration in anticipation of early development of its Steep Rock property.

Inland Steel Co.'s first actual venture into Canadian mining promises to be a mammoth undertaking. Some $50 million will be invested to bring the 1200 acres leased from Steep Rock Iron Mines, Ltd., into production by 1960.

The investment will cover a period of seven years needed for development. Inland's Canadian subsidiary, Caland Ore Co., Ltd., signed the lease for the property and will operate the mine. Caland will have complete autonomy in developing the property, except for overall direction by the parent firm. So far as possible personnel will be Canadian.

Inland has been participating in Canadian ore exploration for the past 20 years, but the Steep Rock venture is its first entry into Canada. The Steep Rock development is especially attractive to Inland because of its location. The property is located at Steep Rock Lake, 140 miles west of Port Arthur, Ontario. A spur, three or four miles long, will connect Caland with the railroad. After rail shipment to the Canadian National Dock at Port Arthur, steep rock ore will be loaded on ore boats bound for Inland steel mills at Indiana Harbor. Port Arthur is 120 miles nearer Inland steel mills than Superior, Wisc., shipping point for Mesabi Range ore.

Test drillings indicate at least 50 million tons of ore in the leased area, with greater tonnages possible. Quality and structure of the ore is considered excellent, according to Philip D. Block, Jr., Inland vice president in charge of raw materials. A shipping volume of 3 million tons annually is expected when in full production. Every attempt will be made to bring the mine into production. Inland is continuing its drilling and exploration program in the area this winter as it has done in the preceding three. First task in bringing the mine into operation will be removal of overburden. Agreement between Caland and Steep Rock runs for 99 years and provides for payment to Steep Rock of royalties based on the market value of the ore shipped. Inland is also making an $8 million loan to Steep Rock for additional working capital to speed development of its own new mines. The loan is repayable after mining operations begin.



One of the iron orebodies exposed by draining Steep Rock Lake has been leased by Inland Steel Co.'s Canadian subsidiary, Caland Ore Co. Map (left) shows location of Steep Rock on Canadian National RR 140 miles west of Port Arthur, Ont. Route of ore boats from Port Arthur to Inland's steel mills at Indiana Harbor is 120 miles shorter than the shipping route for Mesabi ores from Duluth-Superior. Inset map (right) shows Inland lease covering "C" orebody. Steep Rock Iron Mines Ltd. is producing over a million tons per year from "B" orebody and is now developing the "A" orebody.

The C orebody leased to Inland is one of the large orebodies made accessible since 1943 by spectacular Steep Rock engineering operations. Part of the operation involved diversion of the Seine River from Steep Rock Lake and the dredging of the lake. Steep Rock has been mining continuously from the *B* orebody since 1944. It is presently developing the large *A* orebody and the recently discovered *G* orebody in the same area.

Last year the Errington open pit in the *B* orebody shipped 1,275,000 tons. Current operations are now preparing the Errington pit for underground operations to depths of several thousand feet. Production from this underground mine and from the Hogarth open pit in the *A* orebody is expected to begin soon.

Inland is the eighth largest steel company in the world and has a rated steel-making capacity of 4.5 million tons annually. The company owns its own reserves of iron, coal, and limestone, and operates a Great Lakes fleet.

Steep Rock President M. S. Fotheringham said, at the announcement of the Inland contract, "the association between the two companies is already an established one, since for three years Caland has been conducting an extensive exploration program on the orebodies which it will now proceed to develop. Caland's expenditures for such development and for the subsequent long-term mining operation will represent an important contribution to the Canadian economy."

Mr. Block noted that the acquisition will cover Inland's ore needs "many years into the future without the necessity of going to remote sources to supplement the reserves it already has in the United States."

1952 Mineral Production Maintains Dollar Value

BIG news in mining for 1952 was that total value of mineral production maintained the pace set during the previous year, despite a slight decline in production. Decrease in volume could in part be traced to various ills. The steel strike, failure of war production to reach expected levels, and drop in lead and zinc prices contributed to the slight falling off.

Bituminous and lignite coal production in 1952 fell 13 pct below the previous year. Again the steel strike, coupled with decreasing exports and domestic consumption can be blamed. Outlook for 1953 fails to offer hope that there will be any significant surge in production. See Table I.

Table I. Mineral Production, 1949-1952

	1949 (Billions of dollars)	1950 (Billions of dollars)	1951 (preliminary)	1952 (estimate)
Nonmetallic minerals:				
Fuels	7.9	8.7	9.8	9.7
Other	1.6	1.8	2.0	2.2
Total nonmetallic	9.5	10.5	11.8	11.9
Metals	1.1	1.4	1.7	1.6
Grand total	10.6	11.9	13.5	13.5

Iron Ore Production Drops

Supplies of iron ore in 1952 were reduced by strikes and subsequent loss of two months' production during the peak season. However, extraordinary efforts on the part of the producers, plus an enlarged cargo capacity on the Great Lakes reduced the effects of the shutdown. The winter needs of Lower Lake consumers were met.

With the exception of nickel, marked improvement was noted in the supplies of ferro alloys. International allocation plans for cobalt and tungsten were discontinued at the end of the year.

The manganese situation became much more favorable in 1952 because of sharp increase in imports and decrease in consumption as a result of strikes. Similar factors, plus increased domestic production, also led to improvement in tungsten supply. Domestic production of chromite increased 35 pct and imports 13 pct.

International allocation of nickel was continued despite increased Canadian production, resumption of operations in Cuba, and lower rate of Government stockpiling. There was a scarcity of the metal in terms of industry requirements.

Imports of Nonferrous Metals Increases

Domestic production of copper did not increase despite continuing heavy demand. Copper imports were substantially higher than in 1951, because of heavy receipts in the last half of 1952. But supplies continued to be inadequate for all civilian and defense requirements. Copper controls were open-ended February 1953 by the new administration.

In contrast with copper, both lead and zinc changed to a position of relative plenty. Since consumption decreased slightly, supplies were greatly increased by imports. Domestic production of lead was about the same as in 1951, but imports were doubled. Zinc production changed very little while imports increased by about one-third. Prices of both metals declined considerably during the year forcing a portion of the industry to curtail production.

Non-Metallics Up

Production of non-metallic raw materials used in construction, chemical, fertilizer, and ceramic industries increased about 8 pct in total value over 1951. This increase was largely the result of higher values for stone and cement. Fluorspar and gypsum production dropped off in 1951. Decline in fluorspar from domestic mines occurred in the face of record consumption. Imports of fluorspar, on the other hand, established a new record and for the first time exceeded domestic production.

Plant Expansion

Plant expansion as reported by the Defense Production Administration during the first quarter of 1952 indicates a big year. The following tabulation shows expenditures made in plant expansion of projects under certificates of necessity:

Blast Furnaces	\$21,221,000
Steel Works and Rolling Mills	178,661,000
Primary Refining—Aluminum	68,963,000
Iron Ores	18,243,000
Copper Ores	4,181,000
Electrometallurgical Products	13,446,000

This tabulation is by no means complete, but rather indicates strong activity for the year.

Table II. U. S., World Mineral Production

Mineral	Unit	U. S. Production 1951	U. S. Production 1952	World Production 1952
Mineral Fuels:				
Anthracite	Sh. tons	42,670,000	39,947,000	1,895,000,000 Metric tons est. (Anthracite and Bituminous Coal & Lignite)
Bituminous Coal & Lignite	Sh. tons	533,664,732	465,000,000	
*Natural Gas	Thous. cu. ft.	7,457,359	8,100,000	Not available
Petroleum (crude)	Thous. bbl	2,244,529	2,886,995	4,494,063 Est.
Nonmetallic Minerals:				
Asbestos			Canada produces 65% of world production	1,400,000 Est.
Cement (10 months)	Thous. bbl	229,393	237,396	Not available
Feldspar	Sh. tons	400,439	400,000 Est.	Not available
Fluorspar	Sh. tons	341,300	334,000 Est.	Not available
Gypsum (crude) 9 mos.	Sh. tons	5,795,997	5,147,421	Not available
Mica	Sh. tons	72,168		
Phosphate Rock	Long tons	10,775,000	11,500,000 Est.	22,500,000 Est.
Potash	Sh. tons		1,580,000	
Sulphur (in all forms) (total equivalent sulphur)	Long tons	6,196,859	7,000,000 Est.	12,000,000 Est.
Metals:				
Aluminum (ore)	Long tons	1,848,676	1,596,336 Est.	Not available
Antimony	Sh. tons	3,512	2,000 Est.	Not available
Beryllium	Sh. tons	510	559 Est.	Not available
Chromium (ore)	Sh. tons	7,056	20,000 Est.	1951—3,100,000 S.T.
Copper	Sh. tons	928,330	924,469	2,800,000 Est.
Gold	Troy oz.	1,980,663	1,886,036	Not available
Iron Ore	Long tons	116,504,672	97,700,000	1951—293,000,000 M.T.
Lead	Sh. tons	388,164	(Prel.) 384,100	
Magnesium	Sh. tons	40,881	50,000	Not available
Manganese Ore	Sh. tons	101,900	110,000	Not available
Mercury	76 lb. flasks	7,293	12,400	Not available
Molybdenum	Lbs.	38,855,000	32,200,900 (9 mos.)	37,000,000 Est.
Nickel	Sh. tons	756	900 Est.	157,500
Platinum Group	Troy ozs.	36,951	60,401 (9 mos.)	Not available
Silver	Troy ozs.	39,766,779	39,100,923	Not available
Tin	Long tons	88	100	168,000
Titanium Sponge	Lb	1,500,000 Est.	2,200,000	Not available
Tungsten Ore	Lb	5,913,750	6,167,145 (11 mos.)	Free World Only 34,000,000 Est.
Zinc	Sh. tons	681,189	661,000	Not available

* Marketed production.

Four Pacts Signed for Mexican Manganese By DMPA Call for Total 230,500-Ton Delivery

Four contracts calling for delivery of 230,500 tons of manganese ore from 30 to 40 small Mexican mines have been signed by the Defense Materials Procurement Agency. Added to a previous agreement for 50,000 tons, the contracts bring the total tonnage to 280,500 arranged for under a program calling for 550,000 tons. Contracts for the remaining 269,500 tons are under negotiation. The entire amount is expected to be delivered to an El Paso, Texas, depot within the next three years.

DMPA expects to negotiate with a private firm for the construction and operation of a processing plant. Firms involved in the most recently announced contracts are:

Winter, Wolff, & Co., New York; Frank Samuel & Co., Philadelphia; Continental Ore Co., New York, and Industrial Development Corp., de Mexico, S. A., of San Luis Potosi, Mexico. The contract for the earlier 50,000 tons is with Manganese Producers, of El Paso.

Price to the Government under the contracts is $19.30 per long ton for 25 pct ore, with a premium of 70 cents per ton each 1 pct of manganese content above 25 pct. Contracts also call for a penalty of $1.00 per ton for each 1 pct below 25 pct, down to and including 20 pct. Ore containing more than 20 pct silica or less than 20 pct manganese will not be accepted.

Foote Mineral Expands Kings Mt. Capacity

Foote Mineral Co. expects to complete new installations at Kings Mountain, N. C., within the next few months, with ever-increasing quantities of spodumene going to its lithium plant at Sunbright, Va.

Additional mining equipment is already in use at Kings Mountain and new crushing equipment with capacities exceeding 1000 tons per day will soon be installed. Parallel circuits and expanded facilities for handling recovery of tin and columbite byproducts will be a feature of the plant. Total Kings Mountain capacity is expected to triple, according to the company.

Belgium Mine Aid Funds Approved by U.S.

Belgium will get $24,114,000 of counterpart funds set aside during operation of the Marshall Plan for modernization and reequipment of the country's mines.

The funds are expected to make possible Belgian competition with mines of other nations and participation in the six-nation coal steel community.

DMEA Reports 326 Exploration Contracts

Defense Minerals Exploration Administration reports 326 exploration contracts were in force as of Dec. 31, 1952. They covered search for 24 minerals in 28 states and Alaska.

Total estimated costs of the contracts is $18,927,101 with 59.7 pct of the amount furnished by the Government. Contracts ranged in value from $1300 for mica exploration in N. Carolina to $617,355 for Utah lead-zinc exploration. Government participation in the smallest contract was 90 pct and 50 pct for the largest pact.

Total cost of 272 contracts was less than $100,000 each. One hundred and fifty-three contracts involved amounts of less than $25,000 each. Government participation in individual contracts depends largely upon the critical state of the mineral sought.

AS&R Closes Down Ground Hog Mine

American Smelting & Refining Co., reported closing its New Mexico Ground Hog mine in the face of continued depressed conditions in the lead and zinc market.

The mine produced at a regular rate of 15,000 tons of zinc and about 2500 tons of lead per year.

Leviathan Sulphur Mine Makes Debut in 1953

First large scale mining of sulphur in California is scheduled to start sometime next year at Anaconda Copper Mining Co.'s Leviathan mine in Alpine County. Anaconda purchased the mine from Texas Gulf Sulphur Co., two years ago.

Mine output will be shipped to Anaconda's new copper smelter and refinery at Yerington, 12 miles over the Nevada line. Ore will be used for manufacturing sulphur acid for leaching copper ores. Mine production of 300 tons per day is expected.

Only other elemental sulphur operation of any size in California is that of Hancock Chemical Co., subsidiary of Hancock Oil Co.

Central Eureka Corp., engaged in gold mining, announced that it will buy a sulphur deposit at Sulphur Nev., and construct a refinery at the mine site.

Uncover Gold-Silver Vein at Summit King

A vein of gold-silver ore has been uncovered at the Summit King mine near Tonopah, Nev. The mine is leased from Calumet & Hecla, Inc., by Homestake & Bralorne Mines, Ltd.

The vein was encountered in an uplifted fault block at the 300-ft level in cross cutting from the bottom of an existing shaft. Homestake reports no real sampling job has been done. About 260 ft of the narrow vein have been uncovered. A company official noted that the ore was considered of good grade and warranted further development.

A Calumet & Hecla official reported that the vein was discovered about two years ago by diamond drilling. Under an agreement, Calumet & Hecla will receive at least 40 pct of the profits after development.

$2.5 Million For Brazil Mineral Development

Brazil plans to spend some $2.5 million for mineral development during 1953, according to reports in the *Brazilian Bulletin*, published by the Brazilian Government Trade Bureau.

President Getulio Vargas is said to have approved National Mineral Production Department plans including studies on boosting of mineral production, utilization of water power, and ore processing operations of economic interest to Brazil.

Department experiments this year will include underground gasification of coal. Another factor in current plans is the survey underway in the cooperation with the U. S. Geological Survey to evaluate ore beds in the Minas Gerais quadrilateral in the center of the state.

Muscoda No. 4 Mine Closed After 65 Yrs.

After 65 years of operation Muscoda No. 4 mine of the Tennessee Coal & Iron div. of U. S. Steel Corp., has been retired.

The mine's ore reserve has been virtually exhausted, A. V. Wiebel, TCI president said. Operation of the mine began in 1888, two years after TCI moved into Birmingham. The mine has been driven back about two miles from the entrance and reaches a depth of 960 ft below sea level at its lowest point.

Elevation at the tipple is 720 ft above sea level. Maximum distance between the surface and underground workings is 1500 ft. Six TCI ore mines are still in operation at Muscoda and Wenonah.

FROM newspaper reports circulated in Indonesia, it seems quite obvious that many people, even the left-wingers, have serious doubts concerning the wisdom of the Indonesian Government in nationalizing the Bangka Island tin mines, formerly operated by the Dutch Billiton Co. Chief source of American dollars for Indonesia has been the 34,000 ton tin production of its mines. Right now, both left and right are concerned with whether the Government will be able to maintain and increase current production. The right wing Moslem party newspaper, Mimbar Indonesia, stated:

"It will no longer be possible any more for radical labor leaders to find foreign scapegoats and tell the workers they are working only for foreign interests and foreign managements. It is up to labor now to increase its labors for the national good. It will be a new experience, and the problem is whether we are capable enough to manage these important mines."

One radical newspaper commented:

"The problem now is whether we are able to manage it and whether we are able to increase the profits we formerly received. In short, it will be a test of our enterprising ability."

One other point was touched on by the editorial writer, a rather important item. Simply stated, it is the "bitter Truth" that Indonesia has lost on previous attempts at nationalization. In the case of Bangka, the Government is taking a long gamble. The mines supply the major portion of Indonesian tin production. If nationalization fails, the economic consequences might be devastating. Certainly this primary attempt is looked upon as the forerunner of complete nationalization of the mining industry. Billiton managed the mine, which always has been state owned, even under the Dutch administration.

The cabinet is said to be studying the situation of the Island of Billiton, rumored to be completely controlled by the Dutch firm. It is understood that the cabinet favors a five year contract with Billiton, at the end of which time the Government would take over.

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AMERICAN investment, which has played an important role in the development of South America is watching the Latin Americas as the question of nationalism is solved by individual nations. Certainly, U. S. businessmen will tend to partake in the economic life of those countries most favorable to free enterprise. Those countries which nationalize, by the very nature of nationalization, must preclude American capital. Mining engineers returning from Bolivia are proof enough that working under a nationalized industrial organization is an unhappy situation. One point which has stopped nationalization is the realization that American aid, financial and technical, cannot be replaced with psuedo idealism, or dreams of pie in the sky.

Recently, Chile passed laws which gave the Government authority to set the price of copper and also control its export. Some would say that the tendency is toward nationalism. Yet, other reports come out of the country which tend to offer some proof of Chilean favoritism toward free enterprise.

President Ibanez, in an interview with an American business man, is said to have stated that no nation can afford to isolate itself with restrictive nationalistic policies. He further says he considers himself a friend of the U. S., and wishes its friendship in return. But President Ibanez is also a friend of Argentina's Peron, who has been *slightly* negative in his approach to the U. S.

Ibanez, according to H. R. Graham, the American business man and a partner in Guggenheim Bros., gave assurances that the copper and nitrate mining industries would not be nationalized. He has three primary objectives for his people, Mr. Graham reports. They are to increase the welfare and raise the standard of living of working classes and lower paid employees, world markets, and a just and fair price for the things Chile sells, and increased production to defeat inflation.

It may be significant to remember that Ibanez campaigned for the presidency in favor of nationalization. However, it must be remembered that the last time he held office, some 20 years ago, American investment in Chile, especially in utilities, enjoyed a healthy atmosphere. Unlike the detective novel reader, the mining engineer and the investment man cannot turn to the last page to find the answers.

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ALUMINUM Co. of America research men are looking for something to do with gallium. The minor metal has properties that make it almost a shame not to find some kind of application for it. Right now, however, gallium costs $1000 per lb, which is something of a drawback. It melts at approximately 86°F but doesn't boil until 3600°F or higher. It expands upon solidification. Gallium shows marked differences in electrical resistivity and coefficient of thermal expansion along the direction of the three axes of its crystallographic structure. Its resistivity variability is believed greater than any other metal. It emits electrons at extremely low temperatures. Combine all those properties and gallium is obviously a unique metal.

Some uses for the metal exist. It is used in dental alloys for gold restoration work. A patent has been issued for minor use in selenium rectifiers. Its most promising use, however, is a liquid seal on the inlet system of mass spectrometers, where its liquid range and log vapor pressure make it superior to mercury in analyzing hydrocarbons with high boiling points.

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ANTHRACITE coal mine operators have yet another suggestion for solving their difficulties. Glenn O. Kidd, vice president of Lehigh Navigation Coal Co., proposes the merger of all anthracite producing companies into one firm. Mr. Kidd states that such a move would effect economies of $75 million a year and make possible lowering of household coal price by $5.00. Thus far, there has been no

joint discussion or official action on the proposal. There is a feeling in some quarters that the idea may generate a great deal of interest in view of the worsening coal situation.

Before such a move could take place, however, it is obvious that it would require special legislative action on the part of Congress to make it legal. Under the plan, all producers would transfer their property to the newly-formed organization, which would then become the only producer. The firm would be capitalized at 1 million shares of no par value stock to be distributed to present producing firms. Management would be headed by representatives from the northern and southern fields. Only the most efficient and low cost mines would be operated. Enough coal would be produced to meet market demands. According to Mr. Kidd large savings would be made by eliminating standby expenses on days when the mines do not work. A dealer's advisory committee and representations from the United Mine Workers and the Commonwealth of Pennsylvania would be invited to work with the new company.

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REPRESENTATIVES to the Conference on Engineering Education held in London recently found a wide variation in the approach currently in vogue in various countries. At the very beginning of the conference there was difference and confusion over basic terms, such as *professional engineers, practical training, basic science*, and others. But all to the good of the conference, these misapprehensions were cleared away quickly.

In discussing the Humanities, and their place in the training of the engineer, the Americans and French shared practically the same viewpoint, while the Italians were in disagreement. The U. S. idea that such courses were useful only if accompanied by examinations found the Italians maintaining that technical subjects were the prime factor in engineering training. The Scandinavian countries deprecated formal cultural courses and favored arrangements for such classwork made by students.

Definition of a professional engineer led to much discussion but in general the following was accepted:

"A professional engineer is competent by virtue of his fundamental education and training to apply the scientific method and outlook to the solution of problems and to assume personal responsibility for the development and application of engineering science and techniques especially in research, designing, manufacturing, superintending, and managing."

The U. S. and Canada are unique in that recognition of professional status is arrived at through examination and registration. Sweden, Switzerland, Belgium, Norway, France, Holland, and Germany require only a diploma from a college recognized by the government. In the United Kingdom recognition depends upon corporate membership in a professional institution. Denmark falls under all three headings. Written examinations seem to be in order in all countries for those men who do not have formal training but qualify by reason of self education or experience.

HOPE springs eternal in the breasts of proponents of the St. Lawrence Seaway. Every session of Congress brings a new scheme for getting the measure through both houses. This time however, backers of the seaway have brought forth an approach which may appeal to an economy minded Senate. The bill proposed by the previous administration would have cost the Federal Government some $800 million.

The new proposal splits the Truman plan three ways. The power project would be handled by New York State and Ontario. Canada and the U. S. would share in opening part of the river and lake route to permit ocean going vessels to sail as far west as Toledo. It involves deepening and widening the St. Lawrence and deepening a short canal between Lake Erie and Lake Ontario. U. S. financial participation would come from a bond issue to be sold to the general public.

The last step, deepening and widening rivers and channels connecting the Great Lakes to allow ocean going vessels to go as far as Duluth, would be postponed. Key to the whole project at the moment seems to center around a debate currently before the Federal Power Commission on issuing a joint license to New York State and the Province of Ontario for construction of a power plant at Massena, N. Y. If the request is turned down, one of the plan's greatest selling points would be defeated.

Washington observers feel that the plan can get through the Senate, but the House poses an altogether different question. Opposition to the Seaway crosses party lines from Maine to Texas. President Eisenhower, who favored the plan as a five star general on military grounds, is an important factor. His support could mean a great deal for the new plan. George M. Humphrey, Secretary of the Treasury, helped develop the plan when associated with the M. A. Hanna Co., as a means of bringing iron ore down from Labrador. President Eisenhower has been consistent on one point. If the Seaway is to be undertaken at all, he feels the U. S. should participate—but to what extent and for how much he has not said.

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REPRESENTATIVE A. L. Miller (R-Neb.) offered a program aimed at strengthening domestic mining, at the National Western Mining Conference. He emphasized the need for a single government agency to handle all mineral policies. Such an agency would have to have as its head a man who understood the problems of U. S. mining. Representative Miller argues that mining has been seriously hampered by hundreds of confusing regulations. He sees the agency as a clearing house which would do away with the jungle of red tape brought about by the many agencies now in operation and supposedly working toward the same end.

His other points were full use of industrial, productive and inventive genius; tax laws which adjust to depletion allowances; foreign trade in minerals placed second to the welfare of the domestic mining industry; and coordination among all agencies needing strategic minerals.

Drift of Things

AMONG electrical manufacturers, interest in the outlook for copper supplies has not diminished despite signs of a healthier market following price decontrol. Reason: Electrical utility industry output is expected to grow at an average annual rate of 6 pct for the next 15 years. A more graphic description of the growth ahead is given in the Eighth Quarterly Report of the Director of Defense Mobilization as follows: "Power generating capability, which amounted to 63 million kw at the time of Korea, now stands at more than 81 million. The established goal for installed capability at the end of 1955 is 116 million kw. Orders already on the books of power equipment manufacturers, if fulfilled on schedule, will bring installed capability to over 123 million kw by the end of 1956—and more orders for equipment are yet to come."

These statistics portend an impressive requirement for copper, not only for power plants and distribution lines themselves but for the multitude of industry and domestic end-uses.

What of copper supplies to meet this heavy expansion? Supposing a free market for the red metal, it is safe to say that there will be more copper available from both domestic and foreign sources. However, the needs of consumers will probably exceed supplies resulting in a greater consumption of such substitute materials as aluminum.

S. W. Anderson, former deputy administrator for aluminum, DPA, stated in an article in JOURNAL OF METALS, March 1953, that the electrical industry is using extensive quantities of aluminum. It has gained particular acceptance in high tension transmission lines because of its light weight. It is also being used for lamp bases, covered wire, bus bar and smaller sizes of wire used for communication wire, and motor and transformer windings. Stating it another way, the percentage of copper used per kilowatt capacity in 1960 will, we think, be lower than it is now; the converse being true for aluminum.

Two corollary thoughts occur for those shaping future plans. One is in product development. Aluminum, although lighter than copper has a lower current-carrying capacity than copper. This means bigger units and structural parts must be heavier resulting in a heavier over-all weight per machine per kilowatt capacity as compared with copper machines. What the electrical industry wants is a better current conductor, better than copper.

The other is in business diversification. Anaconda Copper Mining Co., fully integrated in copper, has gone into the aluminum business. What copper this company does not have to sell, it can make up in aluminum. This lead deserves consideration by other mining companies whose main source of income is limited by either resources or markets.

MARKET research has always been a nebulous sounding business to us but since a recent interview with a practitioner we've taken to shaking our head with that the-patient's-condition-is-serious-look when corporation executives reply in the negative to our query as to whether they have such services. This particular gentleman was shaping the destiny of a steel corporation, the identity of which we cannot disclose.

Standard operating equipment for the market researcher or statistician, as they are sometimes called, is two offices with ample desk space, one for a battery of secretaries and/or clerks and the other for himself. Long roll statistical typewriters and computers are also essential. We are of the opinion that the researcher should preferably be a good talker, diligent in the presentation of data, and of effervescent personality. The one we interviewed fitted this pattern and, indeed, gave us a free course on business trends—past and present.

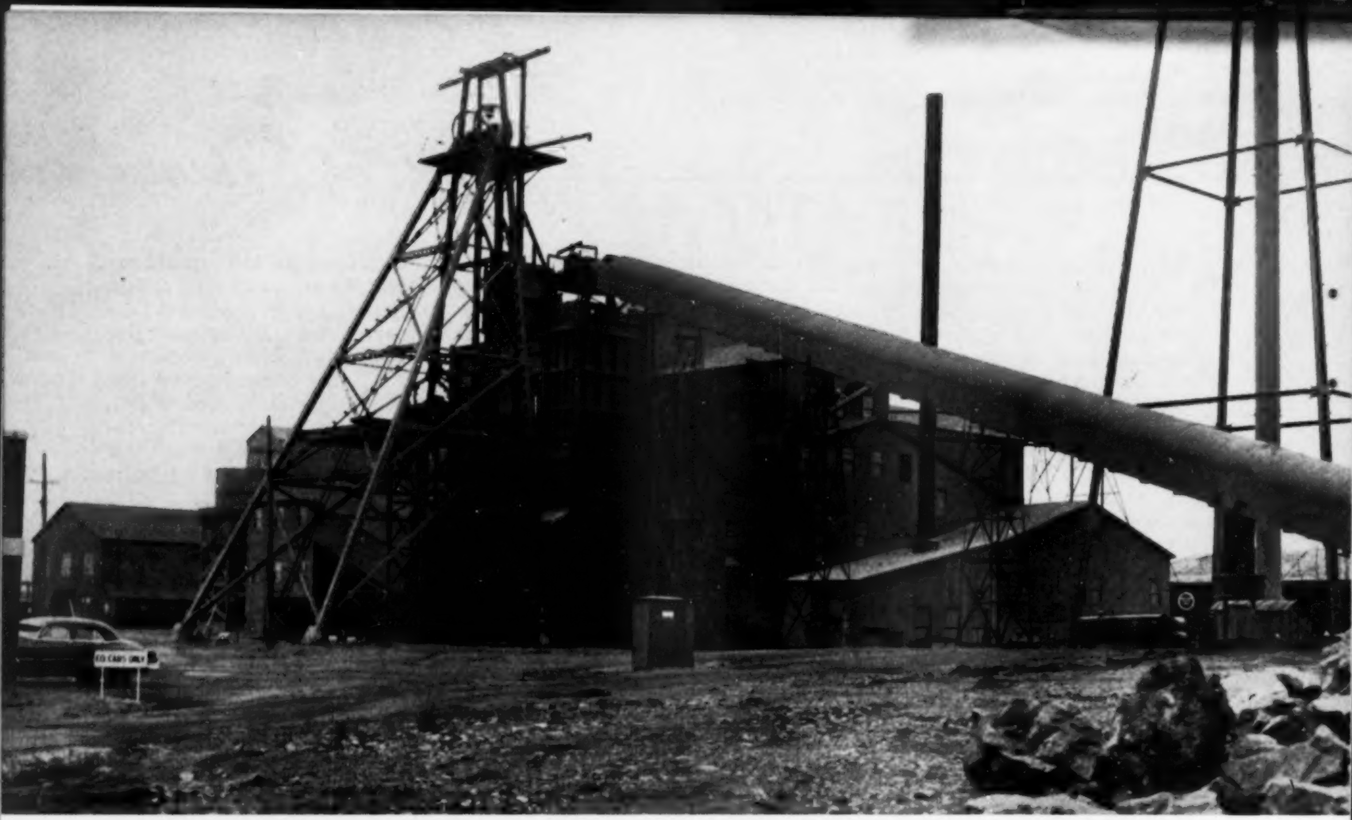
Empire building is all in the day's work for the good market researcher. This calls for spending some of the corporation money or better still borrowing some. This is achieved by studies of business, consumer, population, and industry trends. Can your company expand, merge, buy out, or add a new plant here or there to open a new market or increase services to present customers by product diversification? The good statistician is in and out of Washington, travels the country here and there probing the sinews of economic structure. Once an exploitable area is found he must go into his sales act to drum up interest of the directors. This calls for showmanship—mock ups, graphs, movies, and speeches are all part of the act.

For sales development the researcher is invaluable. When the salesmen are feeling low because business is down, the present-day market researcher can pull out graphs and charts to prove that with expanding population, increased steel capacity, defense considerations and the like, plus a rising trend line since 1939; business must be good because it can't be anything else. If this argument is well bolstered with statistics, salesmen usually begin to feel better (which is half the battle). The follow-through is to pull out a sheaf of prospective customers in embryo industries which have not hitherto been exploited. With a pat on the back new sales energy is unleashed.

These activities require a certain indomitability, resilence, or what have you, as the market researcher often gets slapped down. They are back there pitching the next day though. Any corporation without a good market researcher is dead on its tail.

A PROMINENT corporation director was traveling on a train where he was greatly impressed by the sales ability of an aggressive Union News Co. boy who managed to sell him something every time he came through the car. The director was so impressed he informed the home office to hire this man and put him on the sales force immediately. A reluctant officer put the young salesman to selling coal as he thought he would get into the least amount of trouble in this department. In those days the corporation did not have a training program and the energetic youth made his first sales call with practically no training. The customer's first question was "now what about the Btu's in your coal." Our hero hitched his chair up to the table and waggling a finger at the customer, he said "that's one thing you can't say about our product, we screen them out at the mine."

John V. Beall



Approximately 500,000 tons of ore have been mined underground from the Ozark Ore Co.'s Iron Mountain mine since its reopening in 1944 for open pit work. As open pit production declines the mine is being converted to underground operation with trackless equipment lending flexibility to the operation.

Trackless Equipment Facilitates Change

by W. F. Shinners

Ozark Ore Co.'s Iron Mountain mine utilizes optimum mechanization to provide ever increasing output from underground as production declines from open pit. Trackless equipment gave flexibility to meet varied mining conditions—required minimum of pre-production development.

IRON MOUNTAIN mine is located at the village of Iron Mountain, St. Francois County, Mo., about 90 miles south of St. Louis and some 15 miles from St. Joe Lead Co.'s Flat River operation. The property is owned and operated by Ozark Ore Co., a subsidiary of M. A. Hanna Coal & Ore Co. of Cleveland.

During the 1920's there was extensive underground mining by conventional stopes in both conglomerates and primary ore. The property lay idle during the 1930's and was re-activated in 1944 to mine three open-pit deposits. Drilling during the latter days of the previous activity had established that underground deposits of primary ore were more extensive than previously supposed and plans were laid to have them developed by the time the open pits would be exhausted. Examination of the old stopes revealed that the walls and back had stood for 20 years with little spalling and no caving. It was decided that the rock would stand well enough to permit trackless mining although the shape of the deposit was very different from the type usually worked in this manner.

W. F. SHINNERS is Superintendent, Ozark Ore Co., Iron Mountain, Mo.

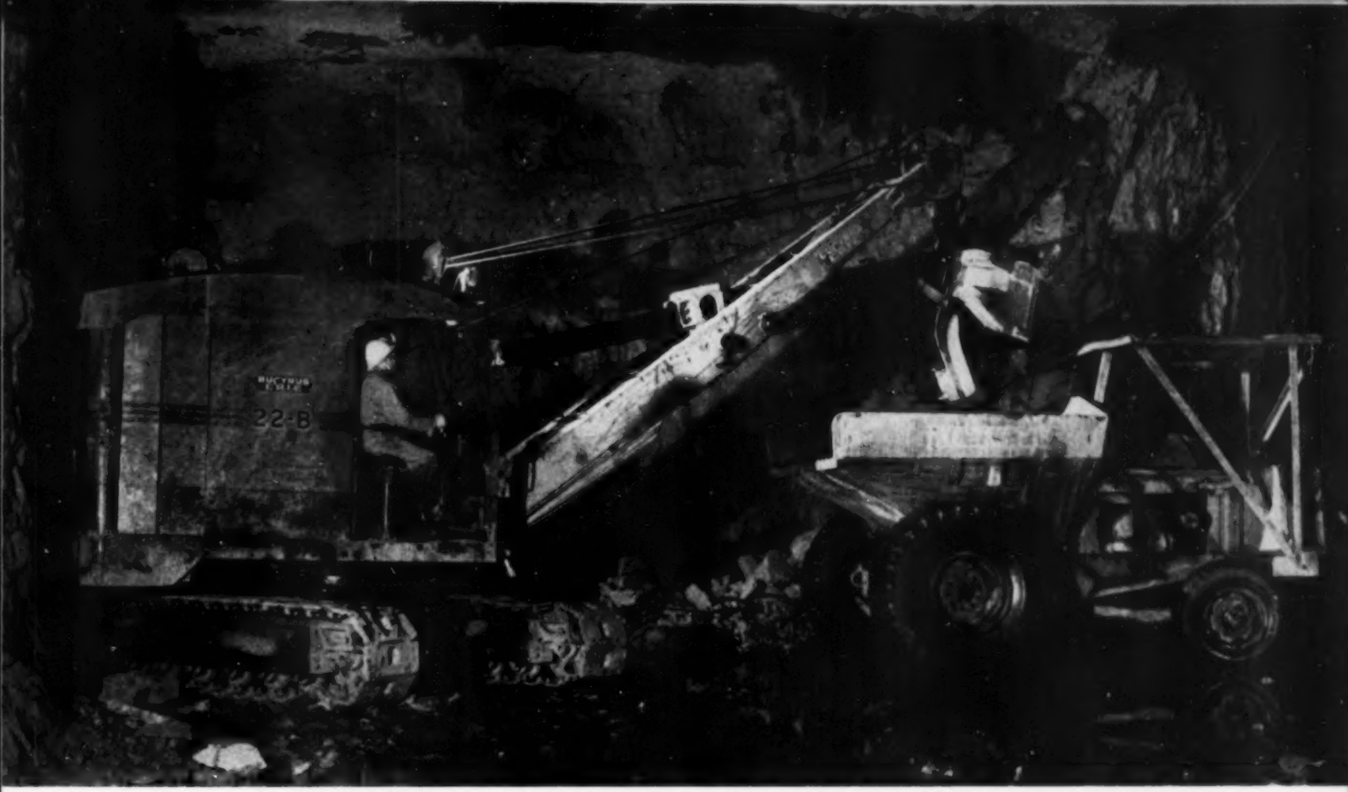
Since reopening, underground work has produced approximately 500,000 tons. It has provided most of the requirements during the past year and will very shortly take over the full load upon exhaustion of all surface deposits.

The main ore body is roughly in the shape of an overturned tea cup with the ore limits confined to the walls of the cup. Both hanging and foot walls are of porphyry. There are no markers to outline the zone, which is quite erratic with respect to both grade and position and varies greatly in width at different places.

Horizontal limits are determined chiefly from analyses of cores from horizontal drill holes at close spacing on each level. Grade of crude varies widely, but averages about 35.00 pct Fe.

Geology and History

Ore deposits are several in number and lie in pre-Cambrian rocks of igneous origin, consisting of andesite porphyry, rhyolite, diorite and granite in-



Three Bucyrus-Erie ¾ yd shovels are used for underground loading. Electric motors are used for main power units instead of conventional diesel or gasoline engine. Koehring Dumptors powered by GM 471 diesel engines are used for haulage. Requirements have been filled by six such units with perhaps one more to be added soon.

from Open Pit to Underground

trusives with extrusives of rhyolite, dacite and some diorite.

Primary ore bodies were formed during pre-Cambrian time by an intrusion in the porphyry of a magma which in working its way up formed a series of large breccia type ore deposits which were coarsely crystalline and contained in addition to specular hematite small amounts of apatite, tremolite and magnetite. Later hydrothermal mineralization served to alter the gangue minerals and was beneficial with respect to present day operation in that most of the apatite was replaced and the phosphorus content of the deposits thereby reduced.

Later day erosion formed conglomerate beds around the higher portions of the mineralized zones and these were overlaid by Paleozoic sediments.

The presence of the Iron Mountain ore bodies has long been known and the out-cropping primary deposits and some of the conglomerates had been worked spasmodically since before 1900.

Mining System

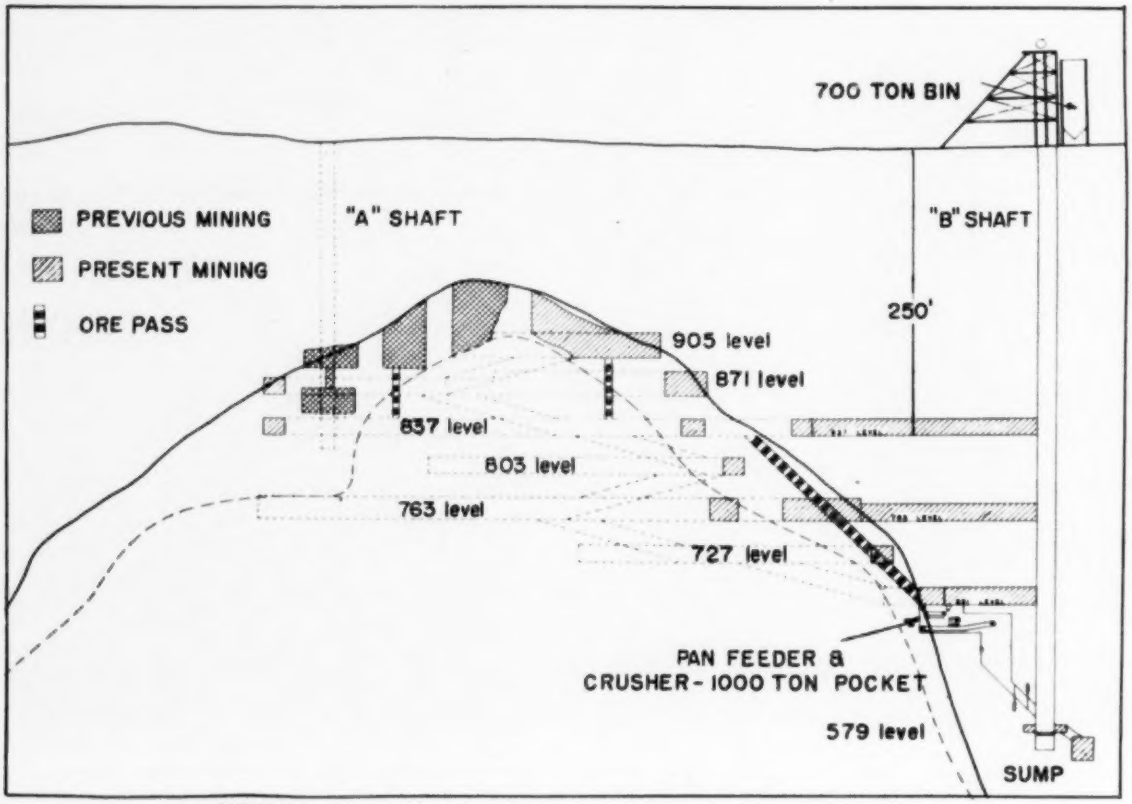
Two shafts had served the previous underground workings, each one reaching the main level at 250 ft. One of these is now used as an escape-way and air inlet and the other, a five compartment shaft with cage and balanced skip hoisting, was deepened to 520 ft to serve the new development. Entrance to the ore body was made at four intervals including the old main level.

Present mining levels are laid out 36 ft apart, each connected with the next by a 15x18-ft incline on a 20 pct grade.

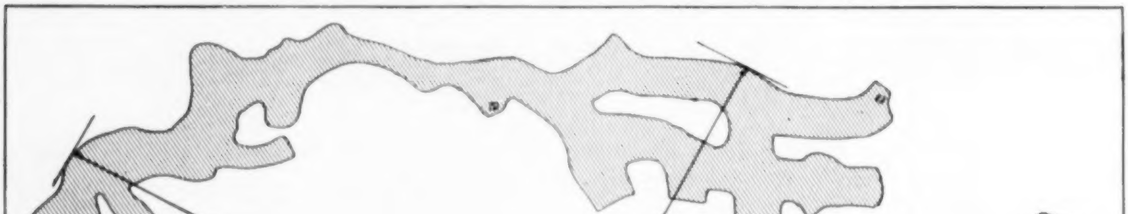
First work began on the second of the shaft connected levels since it was desired to locate the shops, fan, electric transformers, supplyroom where they would be central to future operations. Now, however, with the completion of the inter-level inclines, mining has been started at the top and will be brought down in an orthodox fashion. Four levels are working at the present time.

Extraction began on the second level without benefit of preliminary development. It consisted of driving two headings around the ring, 35 ft wide x 22 ft high, taking side stopes between pillars as width of the ore body permitted. In this particular case a heavier than usual roof pillar was left between the level and the next above since there will be some later hauling which will be partially over mined out areas. In the future, however, it is anticipated that mining above will be finished in the main areas when a new level is opened. In such case the roof pillar will be cut to 12 ft and mining faces carried a full 24 ft high as is now done in some parts of the mine where there is nothing above to be considered.

Pillars are developed, as mining progresses, on approximately 110 ft centers. The exact location of each is a separate study, however, because of the erratic nature of the ore body. The rock between levels will be left at these pillar lines to lend additional transverse support to the hanging wall but



SECTION shows inverted cup shape of ore zone, and four levels being mined presently.



PLAN OF OREBODY shows irregular outline of deposit and locates system of ventilation raises. Numbers referred to: 1—underground shop; 2—"B" shaft; 3—ore pass.

The three Joy Drillmobiles are standard with the exception of heavier propelling motors enabling work on 20 pct grades. Two men drill out and charge in 8 hr on a 38-hole development heading.

will be extracted at all other points if the grade of material warrants.

Development of a level consists of driving a 15x18-ft drift completely around the ore body, cutting diamond drill stations at appropriate intervals. This is not actually necessary, as a preliminary to mining, as it was in the case of the second level, but does help in that it reduces the equivalent of straight face driving on a large scale to a slabbing operation when mining starts. It also provides an opportunity to spot lean areas and to establish the horizontal limits of a level by diamond drilling before large scale extraction begins.

Drilling

Drilling equipment consists of four two-machine jumbos built by the Rogers Iron Works of Joplin, Mo. and three Joy Drillmobiles. The Rogers Jumbos are a crawler type powered by individual electric motor drive on each side and carry Joy Hydraulic Jibs with 10-ft feeds. These machines can put in horizontal holes to a height of 24 ft and cover 20 ft of width. The mast can be tipped back on a hydraulic piston to allow the Jumbo to work in 15-ft headings as shown in the photographs. The drill carriage is raised on the mast by a separate electric hoist and the jibs are controlled by each individual driller from his seat at the machine. In charging, the feeds are slipped back and the Jumbo moved close to the face to utilize the driller's platforms. Three men, one on the ground and two on the machines, form a crew.

The Joy Drillmobiles are standard except for heavier propelling motors enabling them to work on 20 pct grades.

All Jumbo Drills are 3½-in. machines using 1¼-in. round carbon steel rods and 1⅞-in. tungsten carbide bits. The rock breaks well but is extremely hard and abrasive. Average bit life, so far, has been 252 ft with an average of 5.6 regrinds per bit.

Two Jumbos set side by side, with six men, drill out and charge the usual shovel face round of 96 holes in 8 hr. Two men perform the same task on the similar 38-hole round using a Drillmobile.

The average big face round pulls about 7½ to 8 ft and breaks approximately 600 tons. Powder used is Atlas Gelodyn No. 1 in 1½x8-in. sticks and 11½ boxes are required, using tamping plugs. Rounds are fired electrically using regular delays. Very little secondary blasting is necessary. A development round pulls about the same depth with a little higher powder ratio and breaks approximately 150 tons.

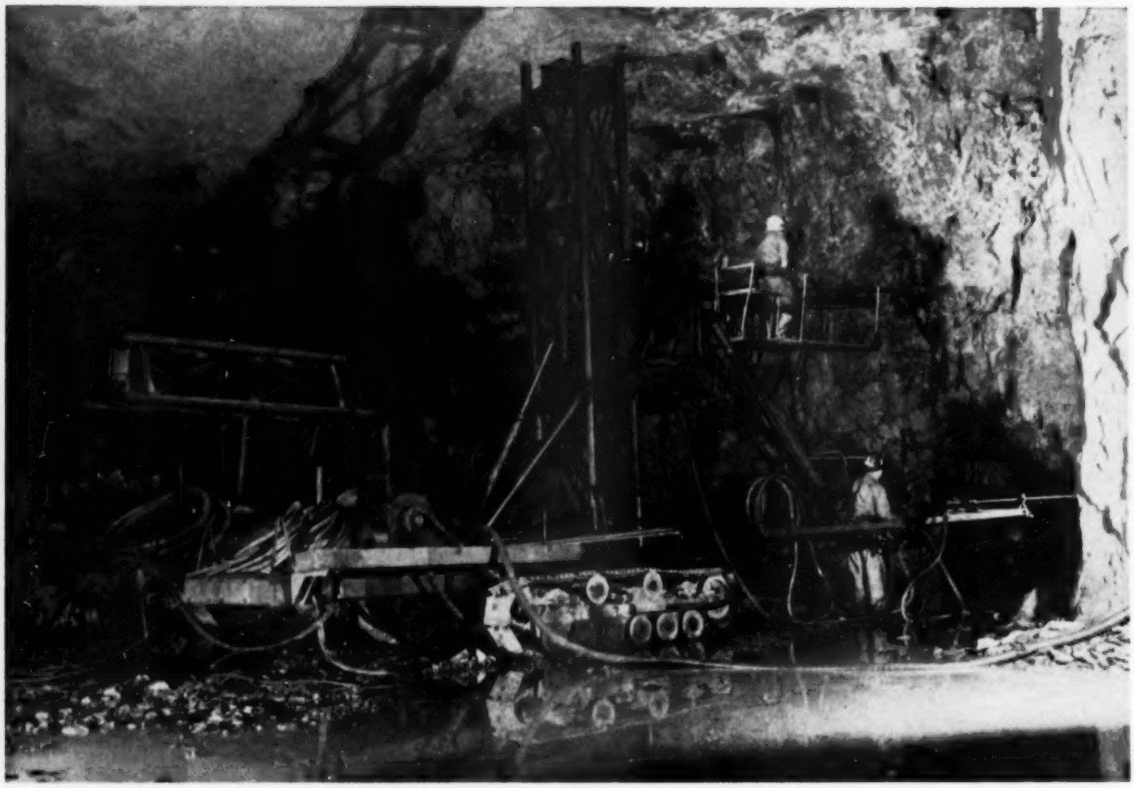
Loading

Loading in the big faces is by Bucyrus-Erie ¾-yd shovels of which there are now three in the mine. They are equipped with an 18-ft boom and use an electric motor as the main power unit instead of the usual Diesel or gasoline engine. They work very well in a 22-ft height and one shovel can easily load 800 tons in a shift.

Three Eimco 104 Loaders equipped with 1-yd dippers are used principally for development work, where a high degree of mobility is required and space will not permit the operation of a shovel.

Haulage

Haulage is by Koehring Dumptors, powered with GM 471 diesel engines. Six have met the requirements to date, but it is anticipated that another unit will be added shortly as length of haul increases and



Rogers two machine jumbos carry Joy hydraulic jibs wth 10-ft feeds. They are powered by individual electric motor drive on each side. Three men, two on the machines and one on the ground, form the crew.

more development faces are added. These machines differ slightly from the standard Dumptor in that they are arranged to drive like an ordinary truck. They haul about 8 tons at a load and have, so far, turned in a very satisfactory performance record.

Two D-4 Bulldozers are used for about the same purpose as in open-pit work. It has been found, however, that they are a little light for the job and it is planned to replace them with larger machines.

Fifty hp tuggers with 5-ft heavy duty scrapers are used to drive the inclines. Muck is scraped to the bottom where it is loaded by shovel or Eimco loader because the grade is too steep for the Eimco to be effective at the face.

A 60-in. heavy duty apron feeder and a 30x42-in. split frame jaw crusher are located at the bottom of the ore pass, crushing ore to 6-in. size before hoisting.

All this equipment had to be sufficiently dismantled on surface to allow it to pass down the cage opening which is 4 ft 8 in. x 7 ft 9 in. clear of the guides. The best time made to date in putting a shovel underground ready to run was 10 days and two Dumptors have been put underground and into operation in 5 days.

Mining Cycle

The mine works at production on two shifts which run 7:00 to 3:30 both day and night. Working faces, both production and development, are shot once per day. The usual procedure is to drill and blast on one shift and to muck, trim, and move in the jumbos on the other.

Since the openings are high and unsupported, thorough back trimming at the faces and continual inspection of all travel-ways is an essential part of the operation. Roof bolting is used to a limited extent but does not find wide application because of the rock structure.

A completely equipped repair shop staffed by a total of seven mechanics, split between the shifts, is maintained on the second level.

Ventilation is maintained by a 75,000 cfm fan located on the second level. It draws its air through a raise from the old shaft and exhausts through vent raises between levels and finally out through the old workings. Auxiliary ventilation to the working faces is usually provided by TM-8 fans set at the closest vent raises. However, in one location where a long drift is being driven to an offset ore body, a 28,000 cfm fan is used and pipe diameter has been increased to 30-in. A short section of pipe drawn down to about two-thirds diameter in the form of a nozzle is placed at the end of each vent line so that the current can be distinctly felt as far as 120 ft from the end of the pipe. All Diesel equipment is provided with scrubbers and, so far, frequent tests have failed to reveal any poisonous concentration of exhaust fumes.

Production

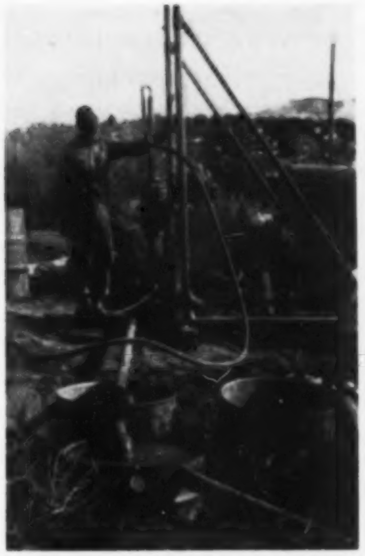
Since production started in August 1951, the mine has been worked in conjunction with the declining open pits, and tonnage has been regulated to suit requirements. At the present time it is in position to produce 2000 tons daily with the prospect of an increase as more working places become available.

The system has supplied the needed flexibility to meet varied mining conditions, has required a minimum of pre-production development and in the opinion of the management has surpassed the results which could have been expected from conventional stoping in this particular deposit.

Cove Creek Sulphur

Diamond drilling of Cove Creek deposits and development of flotation-refining process may lead to commercial operation of property worked sporadically for almost a hundred years.

by Clarence R. King



Light skid-mounted Christensen machine used for exploring reserves. Pipe A-frame welded to the skids was used in place of timber tripod for speed in moving. Note sludge tubs with center well for settling fine sulphur.

THE Cove Creek sulphur deposits are located in Beaver and Millard counties, Utah; close to U. S. highway 91 and about 22 miles north of Beaver, Utah. From 1918 to 1948, production from these surface deposits, except for restricted markets, was unable to compete with Frasch process sulphur from Gulf Coast domes. Since November 1948 realization of the diminishing ore reserves subject to Frasch process mining, and the greatly accelerated worldwide consumption of sulphur has focused attention on all possible sources of sulphur.

Economic recovery of sulphur from the typical low-grade surface deposit presents problems in the specialized fields of the geologist, mining engineer, ore dresser, and chemical engineer. Most of these difficulties result from the absence of previous research effort and technical skill in the exploitation of the scattered and spotty surface sulphur deposits.

Separation of elemental sulphur from its gangue is basically quite simple but in detail is complex, and there are many pitfalls which have resulted in past failures. Marketing sulphur in its many physical and chemical forms and combinations is a complex problem for the operator of a surface sulphur deposit—if full advantage with respect to market outlets is considered in plant design.

Exploration of the Cove Creek deposits, and research upon treatment methods suitable for this ore is not completed; many of the data and conclusions set forth must therefore be considered incomplete or tentative. These notes on progress to date may, however, be interesting to those entangled in the problems of bringing into economic production the surface sulphur deposits of the western hemisphere.

Cove Creek Deposits

The Cove Creek sulphur deposits lie along a large fault, striking north-south to a few degrees west of north; and dipping 40 to 60° easterly. This fault parallels the west flank of the Tushar mountains at the location of the Cove Creek deposits. The known sulphur orebodies, (at present an orebody is defined as a deposit containing 15 pct or more elemental sulphur and subject to open-pit mining with a maximum overburden to ore ratio of 1.5 to 1.) are circular or elliptical in plan; semi-circular or semi-elliptical in section; occupy shallow topographical basins (with two exceptions); are horizontally stratified (again with two exceptions); and carry a gangue consisting of water-worn sand, gravel, and boulders; or water-laid tuff; or fault breccia; or mixtures of these materials.

CLARENCE R. KING is a consulting engineer, Los Angeles, Calif.

All known orebodies are characterized by the presence of large quantities of hydrogen sulphide and/or carbon dioxide gas, which in many cases actively issues from surface outcrops and crevices; or in the case of completely buried orebodies, is encountered in drill holes upon penetration of the sulphur-bearing rock.

All known orebodies contain sulphides of iron, usually of two types. A so-called "secondary" iron sulphide is found intercalated as thin strata or lenses with the elemental sulphur or as a very finely disseminated or semi-colloidal dispersion in much of the high grade sulphur. This sulphide appears to be an amorphous or cryptocrystalline ferrous sulphide. The other type of iron sulphide encountered in the deposits is a finely crystalline pyrite, found as erratic disseminations or massive bodies in the rock underlying the elemental sulphur orebodies.

In addition to the orebodies mentioned above, several outcrops of sulphur-bearing material and gas vents are found on the sides of the steep to rolling hills along the fault line flanking the Tushar mountains. Underground mining, as formerly practiced in Sicily, would probably be out of the question at the Cove Creek deposits because of the large volume of H_2S encountered.

To date, about half of the known sulphur orebodies upon the Cove Creek property have been drilled, but the type, size, and average grade of the remaining unproved orebodies is not expected to vary greatly from those orebodies closely drilled to date. Within an orebody the distribution of the sulphur is much more uniform than is the case in most surface sulphur deposits. The cutoff between ore and waste is usually quite sharp both laterally and in depth. The top of the ore is quite regular. The texture is such that a D-8 dozer equipped with a back ripper can easily mine ore without shooting either ore or the soil overburden except in rare cases where former hot spring vents have formed silicious masses

in the orebody. Overburden thickness varies from nothing to a maximum thickness of 30 ft.

History

Native sulphur was mined from the Cove Creek high grade outcrops in the deposits by the early Mormon settlers in the region. From 1918 to 1946 Utah Sulphur Industries made many attempts to operate the property on a relatively large scale.

During these many attempts to commercially operate the property, no systematic efforts were made to determine the characteristics of orebodies near or below known outcrops of high grade native sulphur. With the exception of a few small "gopher hole" quarries on outcrops of other orebodies, all of the ore treated during this period of intermittent operation was taken from the Sulphurdale orebody, where a large open-pit has been formed.

In 1937 Freeport Sulphur Co. did sufficient "spot" drilling to prove to their satisfaction that the property was not suitable for Frasch process mining, and that the apparent grade of the ore and location of the property with respect to existing markets did not indicate a potentially profitable venture.

Late in 1950, the Chemical Corp. of America acquired a lease with option to purchase holdings of the Utah Sulphur Industries covering 8000 acres.

Drilling and Sampling

Little information was available upon the structure and texture of the ore, and it was desirable to get cores for this reason; as well as for a check upon sludge samples. Diamond drilling was therefore chosen in preference to churn drilling as the sampling method. A factor in this decision was that of speed: at this property approximately five times the shift footage could be obtained in drilling the shallow holes on the 100 ft surveyed grid patterns with a light diamond drill rig than could be obtained with a churn drill outfit. Sampling difficulties would be about the same in either case; with the advantage in favor of the diamond drill if any appreciable percentage of core was obtained.

Diamond drilling was done by the Continental Diamond Drilling Co. under rental contract wherein a fixed fee was paid them for the use of rig and all equipment, plus actual cost to them of wages and operating upkeep. This arrangement was satisfactory and overall drilling costs were quite low; the direct cost per foot of hole averaging $4.25 over about 6300 ft of hole. These costs varied from over $10 per ft in the Sulphur King orebody to less than $2 per ft in parts of the Victor-Conqueror orebody. The average depth of holes was 60 ft.

A line of holes was drilled straight through the orebody until two or three barren holes definitely determined the limits of the ore on that line. The rig was then shifted to the nearest hole in the next line. This method of drilling was made possible by the fact that elemental sulphur is easily "eye assayed" and if present will show as a sulphur-laden froth at the drill hole collar. Apparently about half the sulphur concentrates in this froth.

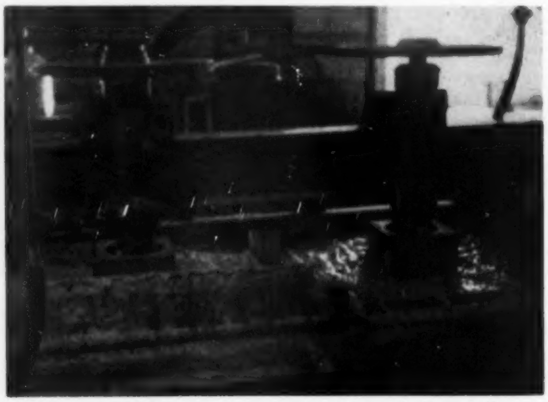
NX hole was run to the ore, and when casting was set into the top of the ore, coring with BX hole started, and sludge return was diverted into the sludge tub setup. Diamond bits were always used in ore, and were changed frequently to insure gauge and sharp cutting. Careful drilling and the use of ball-bearing double core barrels resulted in a core recovery approaching 30 pct, although this varied widely from hole to hole. The Cove Creek ore is very difficult to core due to its friable nature, presence of vugs and alternating soft and tough strata, and the fact that much of the ore is sand and gravel cemented with friable crystalline sulphur.

Sludge sampling and treatment of samples differed in many respects from practice upon metallic ores. Sludge samples were not cut at fixed footage intervals, but were cut at any time a change in formation or apparent grade of ore was noted. Sludge tubs were equipped with a center well, much the same as the feed well in a thickener and with froth baffles around the overflow rim. It was necessary to use two tubs in series to effectively settle the fine sulphur and froth, even though the ore is extremely free settling and contains almost no slimes. There is a tendency to lose sulphur in all stages of the drilling and sampling unless great care is taken.

Results of the Drilling Program to Date

Total footage of drill hole	6,316
Average depth of holes	60 ft
Deepest Hole	172 ft
Shallowest Hole	25 ft
Average direct cost per ft of hole	$4.25
Total short tons of ore proved on 100 ft grid	2,100,000
Short tons proved per ft of drill hole	332.5
Average overburden ratio (ob. thickness/ore thickness)	0.65
Average grade of ore as shown by drill samples	19.8 pct sulphur

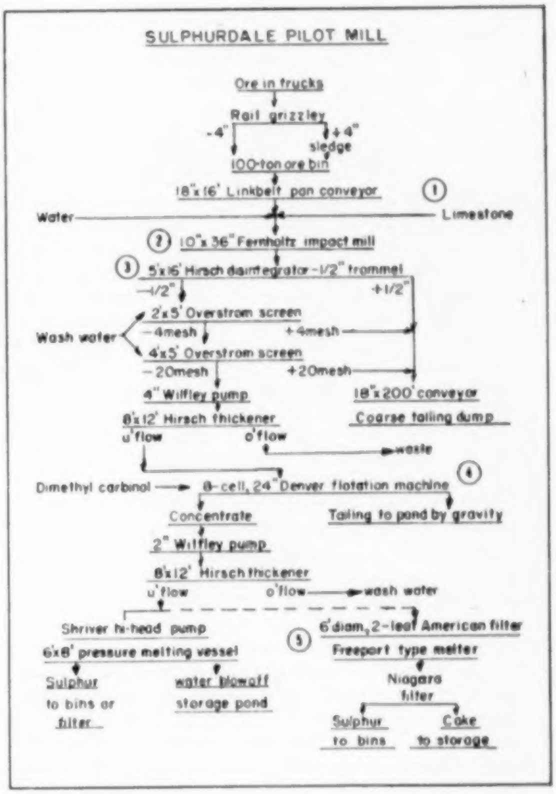
In addition to the above results, isolated holes, test pits, and data from previous work indicate about 1,800,000 short tons of inferred ore of about the same grade as shown above.



LEFT—Mill building and coarse tailing conveyor. Conveyor handled oversize from disintegrator trommel and from the 4 and 20 mesh screens. RIGHT—Sulphur froth on Denver machine. Only reagent required was dimethyl carbinol.

FLOWSHEET of 100-ton Sulphurdale pilot mill shows only radical departure was in crushing and grinding. Numbers refer to circled figures on flowsheet:

1—Pulverized limestone was fed to mill at rate 25 to 150 lb per hr depending on ore. 2—Fernholtz impact mill obtains breaking action from beater arms smashing rock against breaker plates. 3—Hirsch disintegrator, specially designed for mill, used ore as grinding media within shell, had integral trommel on discharge. 4—Flotation was overloaded in comparison to rest of circuit, had capacity of 50 to 75 tons per day; grinding circuit had between 150 and 200 tons per day capacity. Results indicate need for at least 1.2 cu ft flotation capacity per 24 hr-ton. 5—American filter, Freeport melter and Niagara filter installation was proposed to overcome operating difficulties with pressure melting process.



Ore Dressing Research

At the time that the drilling program showed that the uniformity, grade, and tonnage of the sulphur-bearing orebodies would probably result in a potentially profitable venture when drilling was completed; preliminary investigation of the treatment problems was begun under the direction of Roy L. Cornell, consulting engineer of Los Angeles, Calif.

In analyzing the problem, it was concluded that the ore was too low grade to be economically refined directly by any process in successful commercial use at that time. Initial research, then, was directed toward finding the amenability of the ore to froth flotation concentration and toward the best and cheapest method of liberating the sulphur from the gangue and preparing it for flotation. Concurrently with the research upon concentration, preliminary work was started upon possible refining methods to be applied to the flotation concentrate.

Batch flotation testing showed that the ore was readily concentrated by flotation; and that a reasonably high grade concentrate could be made with a reasonably good recovery.

The pH of the ore varied from 1.7 to 2.6 as mined; requiring the use of a neutralizing agent such as lime or limestone unless a completely acid-proof circuit was installed. Because limestone is abundant upon the property, pulverized limestone was tried as a neutralizer. Good flotation results were obtained within a pH range of 5 to 6; buffering action took place sufficient to prevent appreciable attack on machine parts.

Trommel end of Hirsch disintegrator that used ore as grinding media to achieve selective liberation.

Substantially all of the sulphur was liberated at a grind of 20 mesh; and indications were that some means of differential grinding would result in the liberation of practically all of the sulphur with gangue particles much coarser than this.

It was found that both concentrate and tailing were very free settling; concentrate thickener area indicated to settle from 28.5 pct to 56.1 pct solids was 1.2 sq ft per ton per 24 hr. Filter capacity from 56 pct to 85 pct solids was more than 4600 lb per sq ft filter area per 24 hr.

Optimum pulp density in flotation appeared to be about 25 to 30 pct solids. In this connection, a sulphur ore produces a concentrate weighing from 30 to over 50 pct of the weight of the solids in the pulp, and this concentrate is largely removed in the first few cells.

No flotation reagents other than a higher alcohol frother were required, due, of course to the extremely hydrophobic nature of elemental sulphur. Investigation of dispersing agents effective in a pulp of pH 5 to 6 was not pursued; although it is believed that if such an agent is found the ratio of concentration and recovery can both be stepped-up.

A 300 lb per hr continuous test at Denver confirmed batch results and produced ore concentrate assaying not less than 90 pct sulphur, containing not less than 50 pct of the sulphur in the ore; together with a secondary concentrate assaying not less than 60 pct sulphur containing about 40 pct of the sulphur in the ore. If the two concentrates are combined or pulled as one, a total concentrate assaying not less than 75 pct sulphur and containing not less than 90 pct of the sulphur may be made.

Refining the Flotation Concentrate

Conversion of wet, dirty gray, −20 mesh concentrate assaying 75 to 90 pct elemental sulphur into one ore more marketable products was almost as much a marketing problem as a technical question. Some of the alternatives were production and marketing of: (a) agricultural and dusting sulphur; (b) U.S.P. or specialty grades of refined sulphur; (c) both agricultural and special purpose grades; (d) tonnage brimestone grade sulphur.

In order to produce flotation concentrate in sufficient quantity for large scale research upon refining methods and market possibilities; and to enable mill scale research upon grinding and flotation problems the company decided to build a nominal 100 ton per day pilot mill at Sulphurdale.

Preliminary small scale work indicated that melting of the thickened flotation concentrate in an aqueous suspension containing about 50 to 65 pct solids in a closed pressure vessel, followed by filtration; resulted in a clean bright sulphur assaying over 99.7 pct S. The filter cake contained most of the impurities and assayed from 15 to 50 pct sulphur, depending on test conditions. An excess water blow-off during melting carried an appreciable part of the fine and hydrophillic impurities, including most of the semi-colloidal ferrous sulphide.

In order to further test this method of filtration under plant conditions three units each 36 in. diam were built and placed in operation at Sulphurdale. While the units produced clean bright sulphur assaying 99.9 pct; it soon became apparent that it was commercially impractical to use one pressure vessel to both melt and filter the concentrate. Accordingly, a steam-jacketed pressure vessel 6 ft diam by 8 ft high was installed as a melting vessel.

A simple melting process in aqueous suspension graded the product up from an average of 90 pct surplus to over 97 pct, without filtration. The impurities so removed were in the water on top of the sulphur pool in the melter, and were blown off with the excess water. The sulphur so produced was yellow with a greenish cast; filtration produced 99.9 pct bright sulphur, however. During the course of experiments with melting and filtration, over 700 tons of sulphur were produced.

It was concluded that when a large commercial plant was installed melting would be done in a high capacity open pit of the Freeport type, followed by filtration in a Niagra sulphur filter. The melting of an impure finely ground sulphur bearing concentrate in aqueous suspension under pressure has many advantages, but control of the melting and blowoff cycle is too delicate; and control of pH within the melter is too subject to error; to overcome the simplicity, safety, and accessibility of anhydrous open air melting.

Pilot Mill

Design of a pilot mill for the Cove Creek property began in August 1951 and operation began in January 1952. The mill was built at Sulphurdale, site of former processing operations.

Referring to the flowsheet, the only radical departure from standard flotation practice is in the crushing and grinding department. Cove Creek ore consists of thin strata of hard, silicious barren rock as rounded fragments of all sizes from fine sand to fairly large boulders, cemented together with elemental sulphur; and intercalated with thin bands of almost pure sulphur. Our belief was that liberation from the gangue could be accomplished and necessary grinding or scrubbing done by utilizing the gangue itself as grinding media; provided the proper types of disintegrating machinery were used.

Operation of the pilot mill resulted in the liberation of about 90 pct of the sulphur in the ore as a −20 mesh screen product; when about 25 pct of the weight of the crude ore was discarded as a coarse tailing varying from +20 mesh to −4 in. ring size. It is probable that with a different type of impact mill and some recirculation of the +4 mesh material the coarse discard would be reduced to about 20 pct of ore weight and recovery in the −20 mesh product raised to about 95 pct.

No particular effort was made to acid-proof any part of the mill. The only excessive wear noted in about 6 months operation was in the impact mill, where the beater arms wore out frequently; and since the ore is very abrasive, this wear cannot be blamed entirely on acid corrosion. The 4-in. Wilfley pump was not rubber lined and showed normal wear.

pH control in the mill was maintained by the use of pH paper, checked with a Beckman meter. As long as the pulp was maintained at 5 or over at the disintegrator discharge, no acid corrosion was noted. If pH rose above 6 flotation results suffered.

For reasons of policy in no way connected with the technical problems involved, the pilot mill was operated strictly for production of the maximum tonnage of high grade concentrate during most of the 6 months of operation. This seriously hampered experiments with mill circuits and research upon improving metallurgical results. With the flowsheet as outlined, the best results that could be obtained are summarized in the table below.

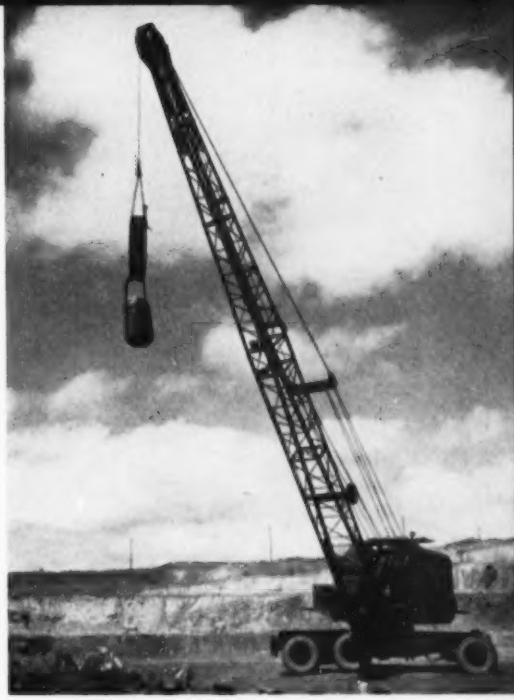
Pilot Plant Results

Product	Wt Pct	Assay S Pct	Sulphur Content Pct
Mill heads	100.0	20.0	100.0
Coarse tailing discard	25.0	10.0	12.5
Flotation feed	75.0	23.5	87.5
Flotation concentrate	16.6	90.0	74.5
Flotation tailing	58.4	4.5	13.0

When the crushing and grinding department was operating near capacity the flotation machine was badly overloaded and the tailing was much higher than that shown; at times rising to 10 pct sulphur. It will be noted that the results in Table II do not equal those obtained in the Denver tests in some respects. The reasons are obvious; the coarse tailing discard losses, and the fact that but one concentrate was made of a grade equal to the highest concentrate made at Denver. Further, no opportunity to make indicated changes in the flowsheet or to bring the mill in balance was permitted under the policy of maximum production of high grade concentrate.

While it is believed that the results noted may be improved by minor changes in the flowsheet, a different type of impact mill and increased flotation capacity, it is an open question whether this type of flowsheet can compete with the Chemico process on this ore. Higher overall recovery of brimstone appears to offset inherent higher operating costs of the Chemico process.

The writer wishes to acknowledge the permission of the Chemical Corp. of America to publish this paper, and to thank Roy L. Cornell for his criticism of the manuscript and his helpful suggestions.



Dropball Cuts Blasting Costs at Tahawus

Here are the facts and the figures on how Tahawus cut costs and improved safety in solving their secondary breakage problem — A dropball crane entirely eliminated secondary blasting.

by P. W. Allen

MacINTYRE Development of the National Lead Co.'s Titanium Div. produces titaniferous magnetite ore from an open cut mining operation at Tahawus, N. Y. Benches at 35 ft vertical intervals permit adequate separation of ore and waste and provide the safest conditions for shovel operation. Higher faces are used only in developing final pit limits in country rock. Approximately 5000 tons of ore are mined each day while nearly 8000 tons of waste rock are hauled to disposal dumps in the same period. Ilmenite and magnetite concentrates are produced by magnetic, gravity and flotation techniques.

The primary crusher is a 48x60-in. Birdsboro-Buchanan jaw set to 8 in. minimum opening. Ore must be small enough to enter the jaw, and the size must also be carefully controlled because the Ross chain feeder ahead of the jaw is not wholly adequate for restraining the rush of the heavy ore as it is discharged from the mine trucks.

Size of waste rock is dependent only on how large a piece the shovel can lift and place in the trucks without damage to the truck bodies. Since 15 and 22-ton capacity Euclids are used, the waste that they haul can be reasonably coarse. Shovels in use have 2½ and 4-cu yd dippers.

Primary blasting at MacIntyre is accomplished by detonating approximately 400 lb of 90 pct straight gelatin dynamite in 9-in. diam churn drill holes. These holes are drilled 39 ft deep behind a 35 ft face, are 16 ft apart in ore or 18 ft in waste, and have burdens averaging better than 25 ft. High strength blasting agent is required by the weight and hardness of the materials being broken. Experiments with hole spacings and dynamite strengths have shown that the 90 pct straight gelatin and the spacings described give optimum results. Under the best of conditions the fragmentation leaves pieces of ore too large for the crusher or of waste too large for loading into trucks.

During the early years of operation at MacIntyre, secondary breakage of the large fragments was accomplished by jackhammer blockholing, but this was soon abandoned in favor of mudcapping. Mudcapping with a 40 pct high velocity dynamite was found to be just as cheap, even though about 5 lb of dynamite per chunk was required.

P. W. ALLEN is Plant Manager, National Lead Co., Titanium Div., MacIntyre Development, Tahawus, N. Y.

In 1945 and 1946 consideration was given to the use of a dropball for secondary breakage. However, it was thought essential to have a crane of 1½ cu yd rating mounted on rubber tires and no crane of that type was available from the manufacturers. The average shovel positions in the mine are such that a crane would have to go 2 miles to complete the circuit. Experience with crawler-mounted equipment made it certain that only a rubber-tired machine could make a two mile trip each day without excessive wear of the running gear.

Apart from the problem of obtaining a suitable crane there was little question that the dropball itself would be an entirely effective and economical device for breaking oversize fragments. The quarry of the Lynn Sand and Stone Co. at Lynn, Mass. was breaking a hard granodiorite with a 6000 lb ball. Mr. Theodore Cooke, president of that concern, was most helpful in providing data about the operation. Similar dropballs were put into use by the quarries of the Lone Star Cement Co. and the Universal-Atlas Cement Co. near Hudson, N. Y. In general, these and other quarries were using a 6000 pound forged steel billet, a non-rotating hoist line and a 1½ yd crawler-mounted crane equipped with a 60-ft boom.

By 1951 there were several rubber-mounted cranes of adequate size available. While a study was being made of the available types, a 6300 lb forged steel billet was purchased from the Cape Anne Forge and Anchor Co. at Gloucester, Mass. A 1½ yd crawler-mounted crane was then taken to the mine to test the ability of the dropball to break the ore and waste fragments. Even though the crane had only a 50-ft boom, the ball acquired sufficient speed in its fall to break the chunks. The brittle anorthosite pieces required only one or two blows, while the coarse-grained footwall ore required three or four.

Because truck-crane combinations require two operators it was decided to buy a mobile crane which

Here Are the Figures

CHUNKS BROKEN BY DROPBALL

	Total Broken	Days Operated	Number Broken Per Day
November, 1951	900 (est.)	22	41
December, 1951	1000 (est.)	20	50
January, 1952	1229	23	53
February "	2292	21	109
March "	2522	21	120
April "	2580	22	117
May "	2948	23	128
June "	2995	20	150
July "	2782	23	121
August "	2840	22	129
September "	2533	21	121
October "	2672	23	116
Total	27,293	261	
Average			105
Average (last 8 months)			125

CRANE OPERATING COSTS

Operating labor at $1.72/hr	$4,120.54
Fuel Oil (No. 208 Diesel at $0.115/gal)	418.74
Maintenance labor	1,533.59
Maintenance materials and misc. supplies (see table below for analysis)	4,632.21
Insurance	124.49
Total	$10,829.57
Days operated	261
Cost per day	$41.49

Analysis of Maintenance Materials Costs

Tires, tubes and repairs		$609.32
Crane repair parts		
Additional boom hoist	$550.48	
Pinion, travel gear and bushings	483.35	
Hoist brake band—spare unit	115.55	
Crown sheave (bought as spare)	177.08	
Plexi-glass	67.02	
Other	143.20	
		1,536.68
Rope clamps		644.26
Hoist rope (10 pcs. 170 ft long; ¾"—18x7 non-rotating line)		741.61
Boom hoist ropes—live (4 pcs. 285 ft long; ¾"—6x19 right lay)		367.74
Boom stay ropes (bought as spares)		223.25
Misc. supplies and small parts		419.75
Freight charges		89.60
Total		$4,632.21

COMPARATIVE COSTS
Dropball Crane vs Mudcapping

		Cost Per Chunk
Mudcapping (1950)		$1.57
Dropball Crane*		
Crane cost per chunk	$0.33	
Billet cost per chunk (worn billets scrapped)	0.13	$0.46
Billet cost per chunk (worn billets resold)	0.069	$0.399

*Projected for year from 8 months

one man could operate. The Osgood Co.'s model 825 Mobilcrane with these specifications was chosen:

Capacity as a clamshell	1½ cu yd.
Capacity as a lifting crane	35 tons at 12 ft radius.
Boom	60 ft long
Boom hoist	independent
Power plant	D 13000 Caterpillar Diesel
Travel speeds	0.65, 0.93, 2.95, 4.20 mph.
Tires	12-12:00 x 24, 16 ply.
Total weight	103,000 lb.

Delivered price of the model 825 Osgood Mobilcrane was $52,000, including a Rud-O-Matic tag line and a 2-kw auxiliary lighting plant. These items were added so that the crane could be used for clamshell or other work as emergencies might require. On the basis of experience with a 1½ yd crawler-mounted clamshell crane, the cost of operating the model 825 Osgood was estimated at $5.78 per hr, including the operator's wage and excluding depreciation. In a year of single shift operation the crane would thus cost about $12,000 to operate. An additional $2000 was estimated as the cost of the dropballs that would be worn out in a year. In 1950, the cost of mudcapping had been $51,000, of which $5000 was for labor and $46,000 for dynamite. The crane and dropball combination was therefore expected to save $37,000 per yr, enough to amortize the cost of the crane in less than 18 mo. The $51,000 spent for mudcapping equalled $1.57 per chunk blasted.

The crane was delivered in November 1951. Operation has so far borne out all expectations and only a few mechanical problems have arisen. The operator became highly skilled in three months and the average of 125 chunks per day, maintained since March 1952, has kept pace with the mine's requirements and entirely eliminated secondary blasting.

Three dropballs were purchased, each weighing an average of 6500 lb. Because of the travelling distances involved it was felt that it would be better to have three balls placed at convenient locations around the mine rather than to have the crane carry one ball to all the working places. After 24,467 chunks had been broken, the three balls weighed an average of 4500 lb each, representing a loss of 0.245 lb of metal per chunk. The initial cost of each billet was approximately $1100. No billet breakage was experienced and, at the average weight of 4500 lb, the balls were still usable although more and more blows were required to break some of the harder fragments. One ball was therefore sold to a quarry where its weight was better suited to the work being done.

Consideration has been given to restoring the worn billets to original weight by welding on a new base, but, it is felt that the balls can be sold for prices that would make such welding uneconomic.

In a year of 260 operating days, a total of 32,500 chunks will be broken if the recent average is maintained. This will consume about 8000 lb of dropball steel. Four balls, weighing 6500 lb each when new, would thus be reduced to 4500 lb each. If scrapped at $0.01 per lb, the net cost of the four balls would be about $4220 or $0.130 per chunk broken. If a resale value of $0.12 per lb (in contrast to the new cost of $0.17 per lb) can be obtained, the net cost would be about $2240 or $0.069 per chunk.

The ability of the Osgood model 825 to handle the 6500 lb billets encouraged us to purchase one weighing 8200 lb. This was placed in operation in late September 1952, and has caused no apparent diffi-

LEFT—Mobilcrane handles 3-ton dropball over front of chassis; also operates over side without outriggers. RIGHT—Operator Lawrence Davis beside 6500-lb billet. Old 1400x24 tire is used as shock absorber, with chain to swivel above, and cable sling below. Hole in billet for sling is feature patented by Mr. Cooke of Lynn Sand & Stone Co.

culties with the crane. Such a billet, if worn to 4500 lb and scrapped, should break about 15,000 chunks at a cost of $0.09 for each one. If sold for $0.12 per lb, the cost per chunk would be only $0.057.

As indicated, the rubber-tired Mobilcrane has never lacked adequate stability for dropball work. Although outriggers are on the machine, they are not used. The boom is usually pointed so that it forms a horizontal angle with the long axis of the machine of less than 45°. When the boom is at 90° from the long axis, the swaying of the machine is noticeably greater but by no means unmanageable or dangerous.

It was found desirable to double reeve and to wind the boom hoist rope on two live drums in order to cut the tension in the boom ropes in half without sacrificing boom hoisting speed.

Hoist line for the dropball has been a ¾ in. 18x7 non-rotating wire rope. This consists of an inner layer of six strands of seven wires each, laid left Lang lay over a fibre core, and around this a second or outer layer of 12 strands, each of seven wires, laid in right regular lay. The wire is preformed. Attempts were made to use ordinary 6x19 right lay wire rope, which costs approximately $0.08 less per ft, but such rope lasted less than 30 min. The heavy dropball, hanging freely in mid-air or rolling among the fragments being broken; unravelled the 6x19 line almost immediately. A heavy-duty swivel will be tried in the near future but it appears doubtful that the device, which costs $75, can last long enough to effect compensating savings in wire rope.

During the first twelve months of operation 1690 ft, or 10 lengths, of the 18x7 wire rope were used. During the crane runner's training period the rope life was limited, but it is now averaging about six weeks.

Crane operating costs shown in the table have totalled $10,830 in twelve months, exclusive of charges for the dropballs themselves. On the assumption that the dollar operating costs have been the same during the early months of dropball work even though the rate of fragment breakage was up to its subsequent level, the crane cost per chunk broken would have been about $0.33. The assumption appears valid when it is considered that, during the first four months, the crane actually worked as much as it did subsequently although the number of "bulls-eyes" with the dropball was less. To the $0.33 per chunk for the crane costs must be added the charges for the dropballs, as discussed above. If the worn billets must be sold as scrap, the charge amounts to $0.13, making the total $0.46 per chunk. The total yearly cost for breaking 32,500 over-size fragments would then be nearly $16,000, in contrast to the $14,000 originally estimated. The wear of dropballs has been approximately twice as severe as expected and accounts for most of the $2000 difference. However, the sale of the worn billets for use as dropballs elsewhere will offset this amount to an extent.

In itself, the handling of a dropball with a rubber-tired crane has met all expectations. Concurrent with the dropball operation we have realized many other savings and advantages. Where it was formerly necessary to blast an average of three times during each working day of the week it is now possible to accomplish all the blasting in two or three days. The mudcapping of 125 fragments per day required approximately three separate blasts, all of which have been eliminated. Although the blasting record at MacIntyre Development has been very good, there were occasionally misfires which occurred when shovel dippers struck mudcapping charges that had failed to detonate when the rest of the series went off. Fortunately, such misfires never caused injury to personnel or apparent damage to equipment, but the dropball has completely eliminated such misfires and other hazards associated with mudcap blasting.

Although mudcap blasting did not throw fragments as far as blockholing, it was still necessary to move equipment far enough away to avoid damage from concussion. All or part of the shovels and churn drills therefore had to move from their operating positions at the time of blasting each day. From one quarter to half an hour was lost in moving out and a like amount in moving back. In addition to the time lost there was also a serious wearing of the crawler mountings.

Introduction of the dropball to MacIntyre and the subsequent development of its application were accomplished by Mr. Charles Begor as mine superintendent and by Mr. Richard Salberg, assistant mine superintendent. After the retirement of Mr. Begor on November 1, 1952, Mr. Salberg has become mine superintendent and carried on the work.

First Gain in Five Years For Mineral Engineering Enrollment

by William B. Plank

PRESENT enrollment of 182,361 students in the engineering schools of the United States and Canada represents an increase of 6.6 pct over the enrollment in these schools in 1951-52. Thus is brought to a halt the steady decrease in engineering enrollment that began with the close of the 1947-48 academic year, five years ago.

The mineral engineering student picture is similarly encouraging. In the United States schools, 9453 students are preparing themselves for positions in the Mineral Industry. This is an increase of 8.3 pct over last year as compared with an increase of 6.6 pct in the total United States engineering enrollment. The rate of recovery for the mineral engineering group is thus more rapid than for the engineers as a whole.

For the first time since the mineral engineering enrollment began to decline the first-year class is the largest of the four classes. However, in the remaining three classes the former decreasing registration will continue to produce progressively smaller graduating classes. It is estimated that next June 2092 mineral engineers will receive their first degrees from the United States schools. This is arrived at by adding the number of present seniors to those in the 5th year of the longer programs. For the different groups the figures are: mining 360, metallurgy 630, petroleum 707, ceramic 137 and geological 258.

Future Trend Hopeful

It is impossible to predict the future trend in engineering enrollment but it seems logical that we may look for larger entering classes and numbers of graduates unless a national emergency requires more men of college age in the armed services. We have about passed through the period when the population of pre-college men was adversely affected by the depression years.

WILLIAM B. PLANK is Emeritus Professor of Mining, Lafayette College, and consulting mining engineer, Morgantown, Pa.

It is well known that the opportunities in the mineral engineering field are much less clearly understood by young men and their advisers than those in any other professional field. Mineral engineering educators, therefore, I have long felt should not only devote their efforts to educating the men in their classrooms, but should continue to take active part and leadership in guidance activities in their field.

Table II. Engineering Student Enrollment Comparison, 1944-45 to 1952-53—Undergraduates and Graduates

Courses	1944-45	1947-48	1949-50	1950-51	1951-52	1952-53
Mining	224	2,459	2,223	1,607	1,338	1,168
Metallurgical	472	4,121	3,887	3,511	2,996	3,085
Petroleum	376	4,665	4,175	3,321	2,699	3,448
Ceramic	190	1,108	998	886	667	579
Geological	?	?	?	1,349	1,027	1,173
Total Mineral Engineers—						
United States			11,283	10,674	8,727	9,453
U.S. and Canada	1,262	12,353				
Chemical	5,082	26,972	19,976	16,323	14,079	15,026
Civil	3,537	31,849	29,109	24,505	21,801	22,393
Mechanical	6,965	56,551	45,632	35,347	30,420	32,791
Electrical	5,934	56,408	45,711	34,105	29,966	32,848
Industrial	?	?	?	?	6,578	6,643
Other Engrs.	18,852	68,117	68,001	59,308	36,123	39,364
Total Engrs., ECPD					147,694	158,518
Other U.S. Engrs.					17,934	18,031
Total U.S. Engrs.			218,712	180,262	165,637	176,549
Canadian Engrs.			6,821	4,285	5,433	5,812
Total Engrs. U.S. and Canada	41,632	252,250	226,533	184,547	171,070	182,361

Table III. First Degrees Conferred, All Engineers, United States and Canada

1942-43	14,714
1943-44	11,155
1944-45	4,724
1945-46	8,219
1946-47	19,272
1947-48	30,018
1948-49	46,934
1949-50	54,441
1950-51	43,762
1951-52	31,660
1952-53	30,490

Table I. Undergraduate and Graduate Engineering Enrollment United States and Canada, 1952-53, 201 Schools

Schools	Courses	Fresh.	Soph.	Junior	Senior	5th Yr. and Others	Total Under-Grads.	Grad. Std's	Grand Total
30	Mining	246	232	260	344	31	1,113	55	1,168
46	Metallurgical	508	458	542	585	169	2,262	823	3,085
22	Petroleum and Natural Gas	1,149	674	627	696	103	3,249	199	3,448
13	Ceramic	121	99	105	125	16	466	113	579
23	Geological	[illegible]	231	247	244	47	1,071	102	1,173
	Total Mineral Engineers U.S.	[illegible]	1,694	1,781	1,994	366	8,161	1,292	9,453
107	Chemical	3,822	2,804	2,263	2,375	1,440	12,704	2,322	15,026
137	Civil	5,323	4,497	3,969	4,406	2,088	20,283	2,110	22,393
132	Mechanical	7,823	6,429	5,339	5,413	4,331	29,335	3,456	32,791
135	Electrical	7,263	5,822	4,821	4,804	3,986	26,696	6,152	32,848
59	Industrial	1,097	1,111	1,105	1,390	370	5,073	1,570	6,643
(Calculated Other Engrs.)		4,665	3,368	2,960	3,048	1,753	15,794	3,037	18,831
92	Unclassified	13,535	911	131	23	5,524	20,124	409	20,533
149	Total Engrs. E.C.P.D. Scls.	45,854	26,636	22,369	23,453	19,858	138,170	20,348	158,518
44	Other U.S. Engr. Schools	5,777	3,583	2,642	2,511	3,397	17,910	121	18,031
193	Total U.S. Engineers	51,631	30,219	25,011	25,964	23,255	156,080	20,469	176,549
8	Total Canadian Engrs.	1,854	1,289	992	1,080	384	5,599	213	5,812
201	Grand Total U.S. & Canada	53,485	31,508	26,003	27,044	23,639	161,679	20,682	182,361

Select Engineer Employees Scientifically

by F. R. Morral

INDUSTRY has yet to find a universal solution to the problem of engineer personnel selection. Today, the choice of the right man for the right job is even more pressing than ever before. The age of the hard apprenticeship seems to have passed. In its place one finds the interviewer who must determine through personal contact and evaluation of college grades whether a graduate engineer will fit into his company's scheme. The problem, as it is constituted today, may be broken into four parts:

Need for better use of human resources (there is a shortage of engineers, scientists, and skilled workers), productivity with higher efficiency, encouragement of personal pride in work performed, and employee's happiness on the job and away from it.

The last three items are somewhat related and the attendant results, unfortunately, make an imprint in everyday life. Absenteeism and job turnover is at a high level. Crime, divorce, ulcers, and accidents are rampant. Is it possible that too many square pegs are being pushed into round holes?

College graduates in engineering and science are expected to grow into responsible positions in production, development, research, and sales. However, on graduation their potentialities are unknown. The colleges have given them *know how, know what,* insufficient *know why;* some *know where.*

Scientific methods seem to be necessary to place the graduates properly. This could be followed by training to help them develop to the maximum of their individual capacity. Eventually, they would step into the available responsible positions. This would help do away with any one, and possibly all, of the problems listed above.

Most companies will admit that employee selection practice is often no more than a *trial and error* proposition. It may be pertinent to ask: How does the college graduate and the company choose the course taken?

At an interview, both employer and employee are on their best behavior, wearing their Sunday suits and best of grooming, and on the watch for the proper choice of words. Grades, activities, hobbies and other factors are discussed. The interviewer points out the glamorous side of his company, benefits, pay, vacations, the presidency as a goal.

Men in the mining and metallurgical industry, particularly in the foreign field, have been able to show that they *had what it takes* and in only a few years rose to responsible positions. In this country some stopped on the way and were satisfied with their place. Others considered themselves misplaced. They were disgruntled but thankful for a living. A few companies have been disturbed about this group and have done something. Some people do something themselves.

All companies are conscious of need to use an individual's capacity to the maximum, since this is the key to successful operation, both from the point of view of the individual as well as that of the company. How successful a company is with their personnel can be discerned in their records on absenteeism, accidents, turnover, promotions and possibly demotions. These records also reflect the company's technique of employee selection and choice of training and rating methods.

Some companies have been looking for scientific methods of selection of professional employees. The choice of such personnel is made by giving batteries of tests, some of which are used in schools. Personality tests have not been as common because more research seems to be necessary to evaluate and use them. In summary, the tests given are: aptitude tests; general intelligence tests; interest type tests; personality tests.

Data obtained from the above tests must be evaluated and correlated with the characteristics or attitudes required by the position. Each job requires proper balance of fundamental attitudes for success. If these match, it may be possible to have a satisfied employee with pride in his job, company, and product. Such a program of psychological tests for graduate engineers might help the mining and metallurgical industry.

How could a better use be made of human resources? By the selection of human beings who have *what it takes* and would *like to do it,* and make it possible for them to earn the proper training. Considerable data is gathered on the human being while he goes through the various stages of life starting with grade school.

Many children are given intelligence tests in grade school, others are given aptitude tests in high school. Some universities give batteries of tests to entering freshmen, and a few college students obtain their own tests. Industrial companies also give tests to applicants.

In conclusion it appears that considerable data is collected, but ignored. Intelligence tests, aptitude tests, interest tests, grades, rating by teachers, psychologists, and professors are available, but only little of this material is correlated in a single continuous personal record. This record could point out the amount and the rate of improvement made by the person, and give information which could be used to permit society to choose and nurse the potentially valuable, but now lost, human resources and put them to the best use. The individual would be advised of his shortcomings and encouraged to overcome them. The company would be better able to direct human beings toward openings where candidates would be happy with the environment and take pride in production. Psychological testing and evaluation programs need not be limited to large companies which have huge personnel departments and possibly their own psychologists. It can be adopted by small companies, if they take advantage of consulting services offered by private and university psychological laboratories. The fee certainly will not be as high as the cost of training the graduate, and the accomplishments may result in repayment in a short time.

A word of caution is perhaps necessary. As in everything else, the services of reputable and competent psychologists should be sought. Further, tests reduce but do not eliminate mistakes in picking the right person for the right job.

F. R. MORRAL is with the Kaiser Aluminum & Chemical Corp., research laboratories in Spokane, Wash.

ECPD Lists Accredited Mineral Engineering Colleges

As a service to its readers, MINING ENGINEERING is publishing the mineral industry portion of the 1952 list of "Accredited Undergraduate Engineering Curricula in the United States." This list, revised annually, is issued by the Education Committee of the Engineers Council for Professional Development, and covers all phases of engineering education. The AIME is actively represented on ECPD, which was jointly organized by the Founder Societies and various other groups interested in the professional recognition of engineers.

Engineers' Council for Professional Development has as its expressed objective the enhancement of the status of the engineering profession. To this end ECPD has a program dealing with selection, guidance, training, and recognition of the members of the profession. The program is carried out under the direction of seven committees, one of which, the Education Committee, has as part of its broad purpose "to formulate criteria for colleges of engineering which will insure to their graduates a sound educational background for practicing the engineering profession."

At the time the committee was constituted there was danger of a multiplicity of accredited lists and accrediting agencies. No one list was accepted on a national basis, nor could there be any assurance of a country-wide uniformity of high standards. One of the major purposes of ECPD was the amelioration of these unsatisfactory conditions regarding accrediting.

ECPD is merely authorized by its constituent organizations to publish a list of accredited engineering curricula for use as desired by those agencies which require such a list. It has no authority to impose any restrictions or standardizations upon engineering colleges, nor does it desire to do so. On the contrary it aims to preserve the independence of action of individual institutions and to promote thereby the general advancement of engineering education. *(Date following school refers to year of initial accrediting.)*

GEOLOGY

Arizona, University of (1950)
Colorado School of Mines
Idaho, University of (1950)
Michigan College of Mining and Technology (1951)
Minnesota, University of (1950)
Montana School of Mines
Pittsburgh, University of (1950)
Princeton University (1949)
Saint Louis University (1951)
South Dakota School of Mines (1950)
Texas, A. and M. College of (1949)
Utah, University of (1952)
Washington University (1948)

GEOPHYSICS

Saint Louis University (1951)

METALLURGICAL ENGINEERING

Alabama, University of (1949)
Arizona, University of (1950)
California, University of (Berkeley)
Carnegie Institute of Technology
Case Institute of Technology
Cincinnati, University of (1948)
Colorado School of Mines
Columbia University
Cornell University (1951)
Fenn College (1948)
Harvard University (Physical Metallurgy)
Idaho, University of (Metallurgy) (1938)
Illinois Institute of Technology (1949)
Illinois, University of
Kentucky, University of
Lafayette College
Lehigh University
Massachusetts Institute of Technology (Metallurgy)
Michigan College of Mining and Technology
Michigan, University of
Minnesota, University of
Missouri School of Mines and Metallurgy
Montana School of Mines
Notre Dame, University of (Metallurgy) (1942)
Ohio State University
Pennsylvania State College (Metallurgy) (1938)
Pennsylvania, University of (1949)
Pittsburgh, University of
Purdue University (1941)
Rensselaer Polytechnic Institute (1938)
South Dakota School of Mines
Stanford University (1952)
Utah, University of
Virginia Polytechnic Institute (1948)
Washington, State College of
Washington, University of
Wayne University (1950)
Wisconsin, University of
Yale University (Metallurgy)

MINING ENGINEERING

Alabama, University of
Alaska, University of (includes Geological 5-yr. option) (1941)
Arizona, University of
California, University of (Berkeley)
Colorado School of Mines
Columbia University
Idaho, University of (1938)
Illinois, University of
Kentucky, University of
Lafayette College
Lehigh University
Michigan College of Mining and Technology
Minnesota, University of
Missouri School of Mines and Metallurgy (Mine; includes Petroleum option (1941); Mining Geology option (1950)
Montana School of Mines
Nevada, University of
North Dakota, University of
Ohio State University (Mine)
Pennsylvania State College (1938)
Pittsburgh, University of
South Dakota School of Mines
Stanford University (1952)
Texas Western College (formerly Texas College of Mines and Metallurgy) (1947) (includes option in Mining Geology and Metallurgy)
Utah, University of
Virginia Polytechnic Institute (1948)
Washington, State College of
Washington, University of
West Virginia University
Wisconsin, University of

Domestic Chrome and Manganese Ores Can Be Upgraded and Utilized

by H. A. Doerner

METALLURGICAL problems relating to manganese and chromium ores have striking similarities. Ferroalloys, essential to the steel industry, are produced from both ores. Most of these alloys are obtained from imported ores, as domestic deposits have not yielded enough ore of metallurgical grade to meet more than a small fraction of vital needs.

A survey of domestic manganese and chrome deposits reveals numerous small, dispersed bodies of fairly good ore, none of which appears to be capable of yielding significant amounts of marketable products. To stimulate development of such deposits and to increase Government stockpiles, General Services Administration is offering \$115 per long ton for limited amounts of chrome ores and \$110 per long ton for 48 pct manganese ores that meet metallurgical specifications, with bonuses or penalties for grades above and below specifications.

Even at these prices, domestic output of manganese and chrome ores is far below metallurgical requirements, and other measures would be necessary to prevent disaster if imports should be cut off by enemy action. Since private industry has little incentive to develop methods for utilizing submarginal ores, this problem became a responsibility of the Bureau of Mines.

A few domestic manganese and chromite deposits are known to contain large bodies of ore that can be mined economically by non-selective methods. These include chrome deposits near Columbus, Stillwater County, Mont., and low grade manganese ores at Artillery Peak, Ariz. Unfortunately, these chrome and manganese ores are not only low grade but will not yield metallurgical-grade concentrates by any ore-dressing treatment.

Chemical methods usually are required to convert low grade manganese and chrome ores into products that meet the specifications based upon high grade imported ores and demanded by producers of ferroalloys. Numerous chemical methods have been investigated by the Bureau of Mines in persistent efforts to upgrade domestic manganese and chrome ores or to convert them to salable products, such as commercially pure oxides, salts, and electrolytic metals.

At its Boulder City station, the Bureau of Mines has had notable success in pilot-plant development of electrolytic processes by which high-purity manganese and chromium metals can be derived from low grade ores. Electrolytic manganese is now produced at a rate of 3600 tons per year, and a plant to produce 6000 tons of electrolytic chromium yearly is under construction. As a result of lower cost and much higher purity, these electrolytic metals are likely to displace those now made by aluminothermic reduction of the oxides. The pure metals are used chiefly in nonferrous alloys, especially those having high strength and corrosion resistance at high temperatures. The cost of electrolytic chromium has not been established by commercial production. If it can be sold for 30¢, the present price of electrolytic manganese, it may become competitive with low-carbon ferrochrome.

The Boulder City laboratory also has shown that battery-grade manganese dioxide and chromate chemicals can be produced from domestic ores at efficiencies only slightly less than can be attained with imported ores used for those purposes. A pilot plant designed to concentrate 50 tons of Artillery Peak manganese ore per day has been constructed, and flotation tests are now in progress. Concentrates will be upgraded with manganese oxide recovered from flotation middlings by a dithionate leaching process. A caustic leach to remove silica will be tested also. Upgraded products will be nodulized to provide consolidated material suitable for charging into an electric smelting furnace.

Such combinations of ore dressing and chemical treatment have been regarded as the only feasible means of utilizing low grade ores that do not yield standard grade products by ore dressing alone. However, chemical beneficiation is so costly in relation to the price of imported ores that it should not be regarded as an economic ungrading step in the production of ferroalloys. Also, installation of chemical treatment plants with enough capacity to provide all the ferroalloys required by the steel industry would take more time and effort than could be spared in an emergency.

Ferroalloy producers naturally demand the best available ores because the higher cost of smelting low grade ore usually will more than offset the lower cost of inferior ore. However, if ferroalloy producers were forced to use low grade ores, they would discover that, in most instances, direct smelting after ore dressing would cost less than chemical treatment followed by smelting.

Current specifications for metallurgical ore are based upon the best grades of ore and should not be considered definitive. They should be disregarded in any effort to find the best method for producing ferroalloy from a low grade ore. One specification regarded as critical is the ratio of manganese or chromium to the iron content of an ore. This ratio to a great extent determines the manganese or chrome content of the ferroalloy and also has some effect on smelting cost and furnace capacity in terms of the manganese or chrome content of an alloy.

The steel industry has become accustomed to certain grades of ferroalloys, and it has been assumed generally that alloys having much higher iron content would not be acceptable. One reason advanced for this view is the chilling effect of extra iron when the ferroalloy is added to the ladle.

Metallurgical chrome ore, normally with 48 pct Cr_2O_3 and a chrome-iron ratio of 3, yields a ferro-

H. A. DOERNER is Metallurgical Consultant, San Francisco. He recently retired as Chief of the Metallurgical Div., Region III, U. S. Bureau of Mines.

chrome containing about 70 pct chromium. Concentrates obtained from Oregon black sands and from low grade Montana chromite contain only 40 pct Cr_2O_3, and the chrome-iron ratio is about 1.5. In the Bureau of Mines laboratory at Boulder City, 5 tons of high-carbon ferrochrome, containing about 55 pct chromium, were made from these off grade concentrates and shipped to the Republic Steel Corp. for tests in open hearth furnace.

Six 100-ton heats of alloy steel were made, using the special ferrochrome obtained from the Bureau of Mines. The average recovery of chromium was 84.9 pct, comparing favorably with that obtained from commercial alloys. Microscopic examination of nonmetallic inclusions and etch tests on polished sections of rolled billets revealed acceptable material from all of the heats.

The GSA price of $115 per ton for high grade lump chromite is subject to a bonus or penalty for variations from the standard grade. Montana chrome concentrates do not meet minimum specifications; but, if the scale of penalties were extended, the GSA price would be $41 per long ton for 40 pct Cr_2O_3, with a 1.5 ratio, or 6.8¢ per lb of contained chromium.

Assume that, by a chemical process, chromic oxide is recovered from a portion of this ore and composited with the amount of ore concentrate required to obtain a chrome-iron ratio of 3. Briquets made from this mixture would contain 57 pct Cr_2O_3; they would be a superior source of standard grade ferrochrome; and, at GSA rates, would bring a price of $151 per long ton, equivalent to 17.3¢ per lb of chromium.

The highest quality imported chromite ore (48 pct Cr_2O_3) sells for $54 per long ton, or 7.5¢ per lb of chromium. High-carbon ferrochrome is quoted at 21¾¢ per lb of chromium. Compare these prices with GSA schedules that offer 17.3¢ per lb of chromium in upgraded briquets, 16.0¢ per lb chrome in standard grade ore, and an extrapolated value of 6.8¢ per lb chromium in a concentrate that does not meet minimum specifications.

During the last war, chromite concentrates were made from Montana ores at reported costs of $35 to $39 per ton, including mining and milling royalties, amortization and trucking to Columbus, Mont. These costs cover only short operating periods at less than optimum capacity and would have been considerably lower in a continuing operation at full capacity. Even with present labor costs, it should be possible to produce concentrates for $35 per long ton, or 6¢ per lb of chromium.

Cost estimates indicate that these chromite concentrates can be upgraded chemically for about 6¢ per lb of chromium and then smelted to ferrochrome for an additional 8¢ per lb of chromium. If the concentrates can be produced for 6¢ per lb of chromium, the cost of ferrochrome will be about 20¢ per lb of chromium.

These same estimates indicate that costs for nodulizing and smelting mill concentrates will not exceed the cost of smelting high grade ore by more than 2¢ per lb of chromium in the alloy. The difference may be less, and it is much smaller than the cost of chemical upgrading or the 10.5¢ bonus offered by GSA. With the same cost for the crude concentrate, the ferrochrome will cost about 16¢ per lb of chromium. This is well below the market price for commercial alloy and even less than the GSA price (17.3¢) for briquets made from upgraded concentrates.

There is no doubt that the steel industry can use 55 pct ferrochrome made by smelting crude concentrates and for most uses would prefer this alloy, if the standard grade could be obtained only at a higher cost. In an emergency, enough 55 pct ferrochrome to supply a large part of requirements can be produced from Montana chromite concentrates in existing furnaces on short notice and at reasonable costs. If mining, milling, and smelting are efficiently integrated in units having large capacities, competitive production of ferrochrome from these ores may be possible.

The same general considerations apply to upgrading inferior manganese ores, and the pilot plant at Boulder City will provide data that can be used to estimate costs on various treatments of Artillery Peak ore. The cost of nodulizing and smelting a flotation concentrate containing 30 to 35 pct manganese will be compared to the cost of chemical beneficiation and smelting of the upgraded product.

Artillery Peak ore has a satisfactory manganese-to-iron ratio, and a standard grade of ferromanganese can be made by direct smelting. Except for lead and phosphorus that must be eliminated before smelting, silica is the chief impurity. Lime must be used to flux the silica, and the loss of manganese may be high on account of the increased amount of slag. However, the high silica will be an asset if manganese ferrosilicon is produced.

At the Bureau of Mines Pittsburgh station, a small blast furnace is used to recover a high-phosphorus spiegeleisen from open hearth waste slag. This spiegel is selectively oxidized in a basic-lined bessemer converter to make a slag containing 55 to 60 pct manganese with a residual metal containing up to 5 pct phosphorus. The converter slag is smelted to 80 pct or higher ferromanganese. Utilization of the high-phosphorus residual molten iron is a problem that must be solved before the overall operation can have commercial applications.

The large amount (7 million tons) of open hearth slag being discarded annually as waste has aroused considerable interest in the possibility of recovering ferromanganese from a material containing 7 to 10 pct manganese. In comparison with this lean material, ores containing 30 to 35 pct manganese must be regarded as relatively high grade, and it would appear that an increased degree of attention should be given to the possibility of direct smelting this potential source of manganese.

There is no magic formula by which a low grade ore can be converted to a marketable product at a cost that does not exceed the cost of producing the same product from a high grade ore. The difference may be relatively small if a product having high unit value is obtained by chemical or electrolytic methods. The grade of ore has more influence on costs if a ferroalloy is produced by smelting. If the low grade ore must be chemically upgraded before smelting, treatment costs will be much higher than the cost of smelting high grade ores.

The grade of ore and mining, milling, and transportation costs must all be compared with the grade and costs of imported ore in estimating economic possibilities of treating ore from any specified deposit. For competitive production of ferroalloys, the milled ore must yield an acceptable alloy by direct smelting, and it must cost less per unit of metal than high grade imported ores when adequate supplies of the latter are available.

Haulage System in St. Joseph Lead Co. Mines of Southeast Missouri

by E. A. Jones

THE Southeast Missouri division of the St. Joseph Lead Co. normally hauls and hoists over 5 million tons of lead ore each year. This ore is mined in the stopes and headings of 20 mines, hauled to a main line system, see above, and transported up to 6.4 miles to ore-hoisting shafts. Average haulage distance is 2.16 miles. A few years ago a distinguished mining engineer visiting this area for the first time remarked, "You do not have a mining problem; yours is a haulage problem." Its relative importance may be gaged by the fact that mine haulage represents about 25 pct of the total cost of mining ore, the most costly single underground operation.

The Southeast Missouri lead belt is a mining district located about 65 miles south of St. Louis. This district is roughly 6 miles wide and 10 miles long. The ore horizon lies about 400 ft below the surface where most of the ore is mined from flat-lying beds of dolomitic limestone.

This paper deals with the central part of the district, namely, that portion which contains a group of interconnected mines all in a central haulage system, serving four hoisting shafts. The two major hoisting operations are carried out at Federal No. 17 shaft and Leadwood No. 12 shaft. No. 17 accounted for about 70 pct of the ore hoisted in the district during 1950, averaging about 14,000 tons per operating day. The underground dumping and skip-pocket system at this shaft is similar to those of the other shafts except that it has two rotary dumps. The other ore-hoisting shafts have only one. It might be mentioned that waste rock is hoisted at still other shafts, hauled off, and dumped on the surface by trucks.

The hoisting shafts are on a connected system of about 200 miles of underground 24-in. gage main line railroad. There is also the Bonne Terre system, with its own ore-hoisting shaft, which consists of 13.5 miles of 24-in. gage main line, located in the extreme north portion of the lead belt area. Smaller outlying mines such as Doe Run No. 12 and Hayden Creek operate on trackless or shuttle car haulage.

In addition to the system of main line haulage, each contributing mine group has its own extensive system of stope or heading railroad. Trackless mining is making considerable headway in the Leadwood and Desloge mines. Here the shovel loads into a shuttle car which in turn dumps into mine cars spotted on the main line track system.

When the merits of underground haulage and surface transportation are compared, it must be remembered that in early days there were many individual

E. A. JONES, Member AIME, is Assistant General Manager, St. Joseph Lead Co., Bonne Terre, Mo.

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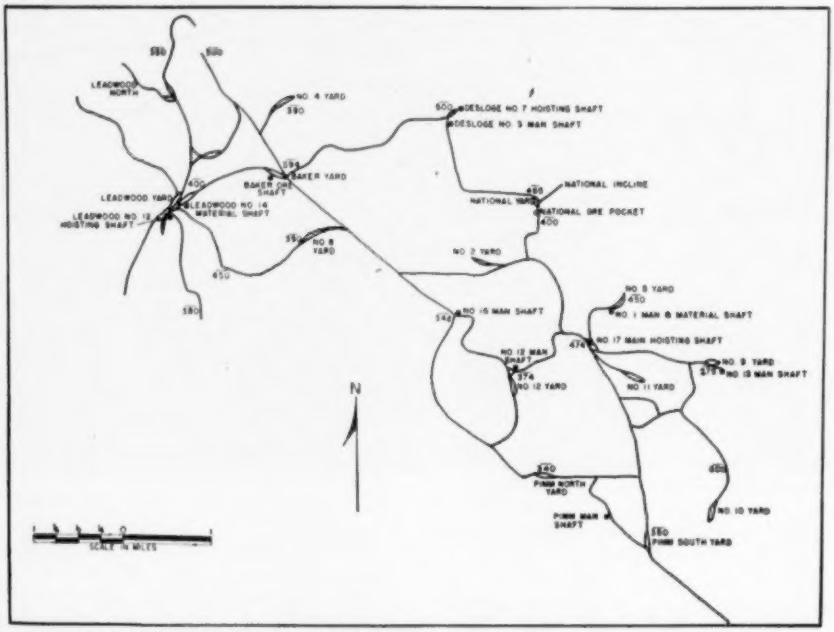

Fig. 1—A diagram of the main line haulage system showing the location of various shafts, the National Incline, and some of the main gathering yards.

mines, each with its ore-hoisting shaft from which the ore was hauled by surface railroad to a mill. As the mines all came under one company operation, it was found more economical to haul to a central shaft where the ore could be hoisted and dumped directly into the mill bins. The mining faces advanced farther and farther from the shafts; consequently there were longer and longer hauls. Tonnage increased with length of haul, and there was a smaller proportionate increase in cost per ton-mile.

An economic limit is reached when the combined costs of drift, track, and trolley exceed the cost of sinking a new shaft, with the attendant expenses of road building and truck transportation. The establishment of this limit is a problem to be worked out in detail for each orebody.

As the production of ore has increased problems have developed and bottlenecks have occurred. These have been met by improving the main lines with reduced grades, increasing radius of curves, and increasing the size of locomotives and cars. Other troubles have been solved by the use of electric switch-throwing devices and traffic signal systems, and by the installation of automatic signals and radiotelephones in congested areas.

The Haulage System

Flexibility in the main line underground haulage system allows for transportation of ore, supplies, or men to Federal No. 17, Leadwood No. 12, Baker, or Desloge No. 7 from any point on the track of the contributing mines. Many other man, and supply shafts are easily accessible, see Fig. 1. In the near future, the National Incline will be ready to handle supplies for all the mines connected to the main line system, which serves 20 mine groups and the two general mines, each under a mine captain. Each mine group has its own haulage system and rolling stock.

The General Mines: The two general mines, Federal No. 17 and Leadwood No. 12, are equipped with extensive shop facilities as well as switching, dumping, and hoisting installations. No. 17 underground shop is one of the largest in the country and is fully equipped to overhaul and rebuild locomotives, shovels, and any other type of mining machinery used locally. Leadwood No. 12 shop, though not as large as No. 17, is well equipped and in the past overhauled and serviced locomotives, shovels, and other mining machinery. At the present time, No. 17 shop specializes in overhauling the St. Joe shovels and all locomotives. Leadwood No. 12 shop specializes in overhauling and repairing the Joy loaders and shuttle cars. The shops proper are supervised by foremen operating under the mechanical department. Track, rotary dumps, switches, skip pockets, and scales are under the supervision of a mine captain. He is responsible for the regulation of all traffic in his general mine area. Ten ore-producing mine groups and one development unit haul to No. 17. Five mine groups haul to Leadwood No. 12, while the Baker zinc ore and Federal No. 6 zinc ore is hauled to the Baker shaft, where it is hoisted to the surface and hauled by truck to the Desloge mill. Zinc ore is also hoisted at Desloge No. 7 shaft, but at present writing this shaft is still in development. Both these latter ore-hoisting shafts have only small mine shop facilities. In addition to the machine shops, large modern underground supply houses are located at both No. 17 and Leadwood No. 12.

Stope Haulage: Actual haulage operations may be divided into three main classes: heading, gathering, and main line. Heading, or stope haulage, is handled by locomotives weighing from 4 to 8 tons which push empty cars into a stope, spot them for shovel loading, and pull the loaded cars to the stope siding. They are equipped with two traction motors and a reel motor. Operation is either from trolley pole or reel. Drum controllers are used with a variety of series-parallel connections. All locomotives have hand brakes, and the newer types hydraulic brakes as well. About 110 locomotives of this class are now in operation.

The motorman, who is trained to operate the locomotives properly, spots empties for the shovel, pulls

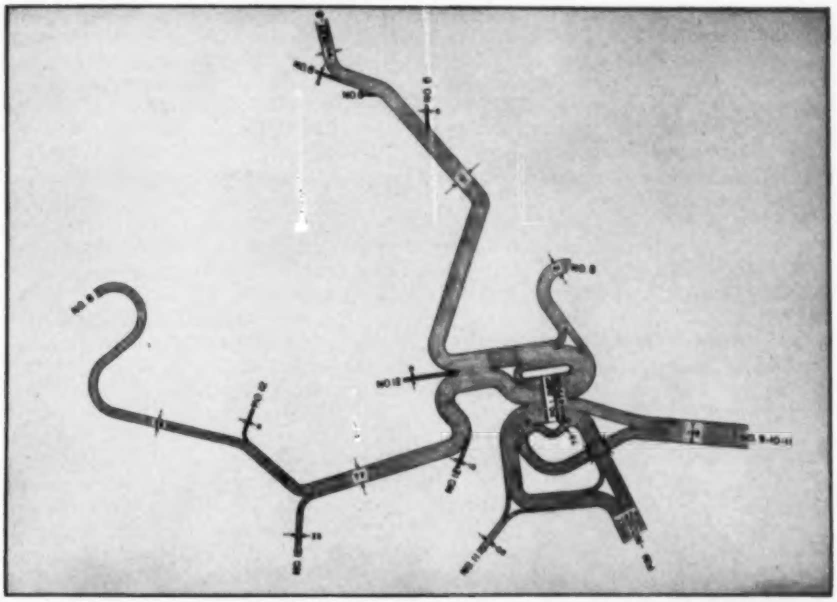

Fig. 2—A flow diagram indicating the traffic density in trains of ore dumped at No. 17 Shaft for week ending Nov. 18, 1951.

the load out to the siding, switches, and pushes in empties again. He also assists his shovel operator, making minor repairs and operating the shovel in emergency. Both members of the shovel crew share incentive bonus earnings equally; good operation is maintained because it is emphasized to the crew that additional earnings can be made from machines with few breakdowns. The captain tells the motorman the maximum loaded cars to move in a train.

Gathering and Main Line Haulage: Gathering and main line haulage may be discussed together since both use the same type of locomotive, ranging from 13 to 25 tons in weight. Gathering consists of moving the loaded cars from the stope siding to the mine assembly yard. Main-line haulage involves movement from the assembly yard to one of the central hoisting shafts. A mine group located in the immediate vicinity of a hoisting shaft may combine these two into one movement.

Nearly all locomotives have been rebuilt and redesigned and may be 2 or 3 tons heavier than when originally received from the manufacturer. They have two traction motors, and all but one use direct connected drum controllers. All have the dynamic braking system, and with the exception of a 25-ton G. E., all have screw-type hand brakes. The 25-ton G. E. has air brakes. Standard accessories on the locomotives include dimming lights, sirens, pole transfer switches, and blowers. A number are now equipped with radio-telephone sets.

As the main line tracks approach the hoisting shaft, the volume of traffic becomes proportionally greater. Since No. 17 hoists about 70 pct of the ore mined in the district, it might be well to examine its traffic flow diagram, see Fig. 2. Ore trains from the various contributing mine groups are pulled into the No. 17 General mine where they come under the control of the rotary dump operator. He regulates the actual traffic to his dump by signal lights.

Dumping and Hoisting the Ore: When an ore train is given a green light, the locomotive engineer pulls it past the dump and over the platform scales where the loaded car weights are recorded, see Fig. 3. Then a switch is thrown and the train is backed to the rotary dump. Here, the actual car spotting is controlled by the dump operator. Three small cars are dumped at a time, or one large car, see Fig. 4. Then the locomotive engineer pulls his empty train over the platform scales where the empty car weights are recorded. The train of empties continues on a circular route until its proper main line is reached.

Unlike the other ore-hoisting shafts, No. 17 has two rotary dumps, discharging into a common skip pocket of about 2,000-tons capacity. Ore flows by gravity into the 8.5-ton capacity skip and is then hoisted about 550 ft to the surface and dumped into the Federal Mill bin.

Haulage operations around No. 17 are protected by automatic block signals for a short distance on all tracks. Beyond the automatic signals are blocks regulated by manually operated red and green signal lights all the way to the gathering loops of each mine area.

The Haulage Problem: The haulage problem varies with the demand for ore, with the location of new orebodies, with the type of ore, lead, zinc, or both, with the introduction of new types of equipment, and even with new concepts of efficiency. For example, when the price of zinc increased to the point where St. Joseph Lead Co. could mine its zinc orebodies at a profit, it was decided to redesign the Desloge mill to concentrate zinc. It was necessary to install a skip pocket, dump, and other facilities at Desloge No. 7 shaft, and until this can be completed, the zinc ore is routed to Baker shaft.

The immediate future calls for many changes in both track and equipment. Long-range planning provides for a number of large projects not yet under way. In general, as the grade of ore decreases more tonnage must be mined, loaded, hauled, and hoisted to produce enough metal to meet demands.

The Supply Problem: In general, the supply traffic is the reverse of the ore and waste rock traffic. Supplies are lowered from the surface in supply shafts,

loaded on cars, and hauled to underground storehouses and shops. At present, all the supplies for the Federal area come down No. 1 shaft and are hauled by the supply crews to the No. 17 supply house. Each mine group makes out an order every two weeks for its anticipated needs. Then the supplies ordered are loaded into mine cars, and are picked up by a main line locomotive engineer to haul back with his train of empties.

As an illustration of the volume of supplies required for track building alone, these mines use about 100,000 white oak 6x8-in. ties, and over 2000 tons of rails of various weights and lengths per year. These figures do not include the large numbers of rails and ties taken up and re-used elsewhere throughout the mines. In many instances broken rails are cut off and a new section welded in place.

Trackless mining is making rapid advances in the Leadwood area. This results in a great reduction of the number of 30-lb rails required, for they are used only in heading track. Track building is one of the major items of underground haulage and elimination of a large portion of heading track would effect a material saving in man-hours and supplies. However, the comparative overall costs of track and trackless mining are still to be determined.

To facilitate further the handling of supplies, work is in progress to put the new National Incline in operation. It is planned to ship supplies directly from the large surface National Warehouses to any mine area without rehandling. This incline will also serve as a faster entry point for the National crews, saving about an hour per day travel time.

The Construction and Maintenance of Underground Railroads

The construction and maintenance of about 200 miles of underground railroad, with the attendant trolley and feeder systems, make up a large part of the expense charged to underground haulage. Most of the newly constructed main lines are laid with 70-lb rail, whereas the older ones were laid with 60-lb rails. Most of the frogs used are No. 5. However, No. 7 frogs are being used in some places. A large portion of this track is laid on creosoted ties. Because large volumes of water may be encountered in development operations drainage ditches are carried alongside the main line track, especially in drifts. Keeping the track above water level makes a much better road bed, and a longer lasting track in general. Because of the age of the district, large areas have been mined out. In many cases the main line track is routed through these old mined-out areas, and laid on fills or in ditches depending on the relative elevations of track and old stope bottom. Here the creosoted tie is used to prevent loss from dry rot.

Fig. 3—Weighing ore cars on the platform scales at No. 17 Shaft. Note speed at which the ore train is weighed. After being dumped, the train of empties will be reweighed to determine the net weight of ore per car.

The typical main line drift is about 11 ft wide and 9½ ft high. A water ditch between 1 and 2 ft wide is generally located on one side of this drift. Signal wires and power lines are hung on one wall, and the airlines are either hung on the wall or placed on the ground on the opposite side of the drift from the water ditch. Trolley wire is installed 7 ft above the rail, and offset about 8 in. to one side of the track. It is generally accompanied by a feeder line ranging in size from 300,000 to 1,000,000 cm. With the advent of the mine radios, an antenna wire is generally installed above the trolley wire.

The Three Classes of Track: The St. Joseph track system may be divided into three classes. The first class system includes the most heavily traveled section of the main haulage line. The second class system also is a part of the main haulage system but carries far less traffic. The only differences between this and the first class system is that there are fewer treated ties and more 60-lb rails. The third class of underground railway is heading track from gathering loops to the stope headings. This track is constructed of 30-lb rails and No. 3½ or No. 4 frogs laid on untreated ties. To facilitate loading piles of broken ore much of this track is shifted either by trackmen or shovel crews. Trolley wire is extended only far enough for the reel locomotives to operate up to the shovel. Little attention is given to this track bed, and generally no bonding is used.

The main line, both first and second class, is constructed and maintained by track gangs assigned from each mine group. A gang generally consists of a track foreman and 6 to 8 trackmen. Each gang has up to 20 miles of track to maintain, working on day shift only, and all maintenance work is done under traffic unless several hundred feet of track must be relayed. Such a job is carried out either on split-shift or on Saturdays. The track gang is subject to call at any time to clean up wrecks and derailments, but most of the crew's work is track maintenance. The gang is responsible for construction of new track in drifts and other development projects, shifting and extending heading track to facilitate shovel loading, and supplying men for any odd job which may turn up.

Track Maintenance: Among the principal items of maintenance costs are drainage and keeping the track clean. If drainage ditches are not kept open, water rises under the track, the joints start pumping mud, ties begin to rot, and in a very short time the track requires a complete overhaul. Mechanization of this type of work underground is not so feasible as on the surface. Hence the pick and shovel in the hands of a man is still about the sole means of track maintenance. Mechanical track cleaners have been tried with only fair results.

The trolley and feeder systems are installed by the mine electricians, who also install the electrical signal systems, the electrical components of the automatic switches, the antenna for the radio-telephones, and any other type of wiring. However, the trackman installs the rail bonds and welds in new rail

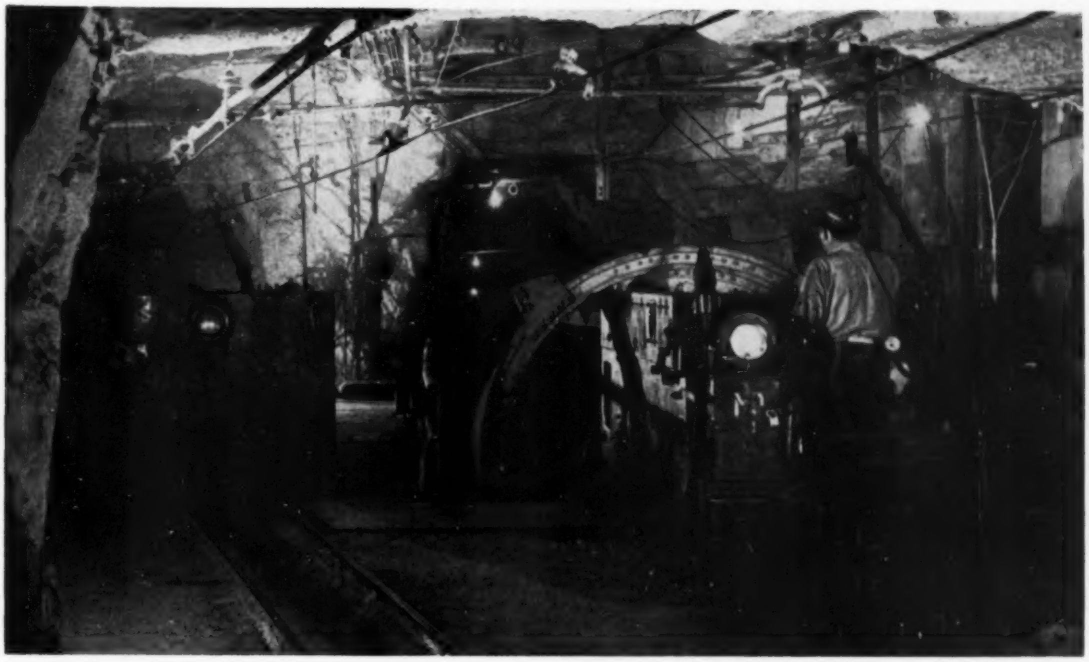

Fig. 4—Dumping a 12.5-ton car in one of the No. 17 rotary dumps. Note the two 15-ton locomotives and the wiring systems. Actual car spotting is controlled by the dump operator. Three small cars can be dumped, or one large car, as shown here.

pieces and angle bars. There are differences of opinion concerning the relative efficiencies of the copper wedge type of bond and the welded joint.

It is difficult to assess the value of a high standard of track maintenance. The benefits derived, such as the reduced wear and tear on the rolling stock, the reduction of accidents which may result in deaths and injuries, and the reduction of haulage delays are not readily expressed in terms of dollars and cents. The experiences of other companies, both mining and railroading, serve as a guide in determining the degree of haulage maintenance which can be justified economically.

Despite a number of adverse conditions St. Joseph Lead Co. has steadily increased production. First, the orebodies become smaller, requiring a greater number of operating places. Secondly, the main haulage lines become longer year after year, and require a proportionally greater volume of materials and manpower for construction and maintenance. Thirdly, the shortage of materials and manpower during the war often resulted in the use of inferior products and sometimes the employment of an inferior type of man.

The above problems were met and solved in a number of ways. The large underground shops of the two general mines were well supplied with both machines and experienced men and not only corrected mechanical weaknesses of the rolling stock as they became evident, but also added a number of improvements in both structure and equipment. The shops were materially responsible for overcoming the mechanical weaknesses of the locomotives and also for improving their braking system, reducing the safety hazard on steep grades. The track gangs were able to reduce many grades and in certain cases to build new haulage lines to bypass the more critical areas. Nothing could be done to decrease the length of the haulage system appreciably. However, by further improving the control and signal systems, it was possible to handle a greater tonnage per operating shift.

The Mine Locomotives: The Federal No. 17 underground shop overhauls all district locomotives, which range from 2 to 25 tons in size and consist of seven different makes, each make including two or more size ranges.

Locomotives of the 13-ton and heavier class are used on main line haulage; the smaller reel-type units are used for heading motors and for utility work. All locomotives, except the 25-ton G. E., are equipped with screw-type mechanical brakes and dynamic braking. While very dependable, the manually operated screw-type brake requires time and effort before it becomes effective. Therefore, when quick stops were necessary to avoid accidents, it was the common practice to reverse the motor as a means of braking. Recently, hydraulic systems have been installed on two 13-ton locomotives which appear satisfactory so far. This system has an operating valve which controls the brake-cylinder pressure, making it possible to obtain the degree of braking

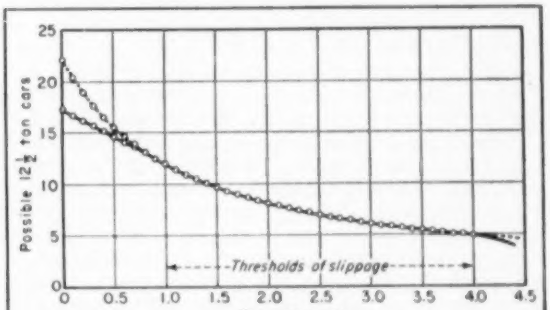

Fig. 5—A graph showing the number of 12.5-ton cars of ore which may be pulled by a 15-ton locomotive at various grades.

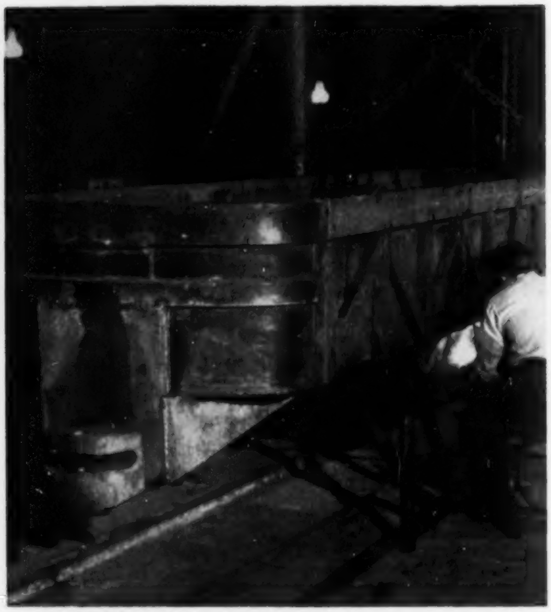

Fig. 6—Building the new type of 12.5-ton ore cars in the No. 17 underground shop. Cars have all-welded construction.

desired. An accumulator tank in the system is sufficient to brake the train in event of power failure.

The principle of dynamic braking was introduced to the district with outstanding success over 15 years ago. While this is effective only on a locomotive in motion, it is ideal for controlling the speed of the ore trains. This method of braking requires a special controller with a dynamic braking position which completes a circuit when applied, converting the motors of the locomotive to dc generators. The locomotive drivers turn the generator and generate power which is dissipated in the system. Naturally, the braking effect results from the energy required to turn the generators. Any break in the dynamic braking circuit immediately renders the whole system ineffective. Other than improvements on the wiring and materials, this system has not been changed from the beginning.

In 1937 a 25-ton G. E. locomotive with air brakes was purchased. This type of brake has proved to be very satisfactory.

A new type of brake shoe is now being adopted on St. Joseph's locomotives. The old shoe and clevis unit were integral and fitted rigidly on the brake beam. The new shoe and clevis unit comprises two separate parts which fit together with a hinge pin. This arrangement allows the new type of shoe to fit itself to the wheel and thus evenly distributes the wear. Also it is necessary to replace only the new shoe, which weighs about 50 pct less than the old type and represents a saving in material and labor.

Fifty-three gathering and main-line locomotives are now in operation. During the past several years, numerous tests and studies have been made including maintenance costs, determination of car factor and weights, power, average track-trolley conditions, grades, locomotive characteristics, and operating methods. Performance data covering several months were reduced to graphs and tables, the grade being used as the common abscissa and data concerning demand, cost, power, tons, and cars being used as the ordinates. This group of curves was furnished to the supervisors to assist them in solving haulage problems in view of operating conditions. In these graphs, solid lines indicate actual values, and dotted lines show the theoretical. Actual values show loads which can be started and moved with the minimum of maintenance and operating costs. Each operating point on the graph is in the apex of a V curve of total costs vs number of cars or tons. This curve, see Fig. 5, seems to be nearly the same shape for all grades and operators. The point used is from a curve for average track and an average operator. Poor track or a careless locomotive engineer would displace this curve upward in its entirety, while excellent track and locomotive engineers would displace it downward. Extremes in either direction would move the curve to the right or to the left in addition to the vertical movement. However, these are not considered to be within the operating range. Thus if the system is properly designed, maintained, and controlled, the locomotive engineers only increase or decrease the costs without affecting the tonnage hauled to any great extent.

To use the graphs, the supervisor first determines the steepest significant grade for the run in question and reads the load from the curved line. On some parts of each run the locomotive is operated at its maximum capacity.

Mine Cars: Two types of standard mine cars are used in St. Joe mines today. The older type has a capacity of 48 cu ft, or about 2.6 tons of ore. It has a swivel coupling on each end, designed for use in the rotary dumps without uncoupling. In the Federal area these cars are used almost exclusively in development work behind the Conway loader. Leadwood, Desloge, and Bonne Terre still use more cars of this type than the other for hauling ore from the stopes. At present, there are about 1560 of these cars in service in the Leadwood-Desloge area, and about 1900 in service in the Federal area.

The new type of standard car, see Fig. 6, is about the length of three 2.6-ton mine cars, or 24 ft. It has a capacity of 220 cu ft, or about 12.5 tons of ore. It has the same kind of swivel coupling at each end so that mixed trains may be dumped in the rotary dump without uncoupling. At present, 620 of these large mine cars are in service. These cars have proved to be far more efficient in both loading and haulage operations than the older type. The last 100 large cars purchased have been equipped with roller bearings for test purposes.

The first group of the 12.5-ton mine cars was introduced in the Federal area about 1941 and tested over a long period of time. It was early apparent that despite the many problems that had to be worked out, the big car had many advantages over the 2.6-ton car. It occupied the space of three small cars but had the capacity of almost five, a great advantage in both switching and shovel loading, and much shorter trains could carry the same volume of ore on the main line track. The coil springs made easier riding cars, and this in turn greatly reduced the wear and tear on the track joints. Excessive mucking was eliminated by adopting a rounded bottom in the big car. It is now anticipated that the roller bearings will effect a savings in both lubrication and maintenance. Moreover, this type of bearing should have less starting friction.

A few of the A-dump type of cars are also in service for the purpose of utilizing waste rock to build fills for the track system. A small number of 2-ton mine cars for operation on the 30-in. gage

track are in service on the upper level of the National mine.

The rubber-tired shuttle car is making a very impressive showing in the Leadwood-Desloge area. Shuttle cars are also being used in the Doe Run and Mine La Motte areas. The new mines, Hayden Creek and Indian Creek, are being designed for trackless mining entirely. Although this paper is concerned with rail haulage, it must be kept in mind that in the stopes and headings a shuttle car has a number of advantages over the conventional mine car which requires an extensive track system. Although the shuttle car range of operation is still limited, haulage distance of the shuttle car trolley system has been extended to better than 2000 ft between the heading and the dumping point.

In the Mine La Motte area and the recently opened Doe Run mine, diesel trucks have been operating between the loader and ore bins. While their tonnage of ore is not very significant to date, this type of equipment appears ideal for open pit and those shallow mines having a truck roadway running underground.

Electrical Equipment and Installations

Power is delivered from the surface transformer stations underground through drill holes to the motor generator sets at 440 v ac. These in turn deliver power at 275 v dc to the trolley systems. The 440-v ac power is also run to the shovel transformers and operates the shovels at 220 v ac.

The Motor Generator Sets: The 45 motor generator sets supplying dc power to the trolley systems are rated between 100 and 300 kw. All generators are compounded, and most motors are synchronous with full automatic controls. Generator stations are semi-permanent installations, and are carefully constructed and maintained, see Fig. 7. Many operate continuously for both haulage power and for general power factor correction.

Regulation is obtained by a careful study of the location of the set. Four different areas are recognized in the setting regulation. If the set is at or near a central hoisting shaft, the location would be called *central*. If out a short distance on a main haulage line serving three mines or the equivalent, it would be considered as an *inner route* location. If further out on a main line and serving two mines, it would be considered an *outer route* location. If located in the outer zone serving only one mine, its location would be considered *fringe*.

Fig. 7—Two large motor generator sets with panel board located in the No. 17 underground shop. Sets of this type supply dc power at 275 v and 1800 amp.

Fig. 8—The 12.5-ton ore car showing reflector tail light and hinge-type stubby trailer.

If the central location has a regulation of V volts, then the following zone would be V plus 10, the next V plus 20, and the fringe V plus 30. This provides an increasingly stiff system, electrically, as the central area is approached. In turn, it permits the outer machines to retire from the load sufficiently to force adjoining sets to assist. This allows the outer set to stay on the line, increasing the power capacity available at a slightly lower voltage. Since haulage loads are transient in nature, the generator circuit breakers are set to open at a rather high current value. Normally, these ratings are set for between 75 and 100 pct overload based on the rating of the machine.

Trolley and Feeder Systems: The track and trolley-feeder systems have been built upon the twin standpoints of capacity and maintenance. Either welding or wedge bonding is used on the main line rail joints, with welding for the heavier loads. Weld joints show conductivities between 130 and 150 pct of that of the solid rail. All trolley is size 4/0, which has proved to have good wearing life and reasonable current-carrying capacity. Where heavier loads are to be handled, a feeder is added, sized in proportion to the load. Feeders are held in slings directly over the trolley for best usage of copper and trolley insulators.

Signal Systems: All traffic is controlled by some kind of signal. The general areas in the vicinity of the two central hoisting shafts are under the control of the respective general mines. All other traffic is controlled by a pull-type system of red and green signal lights initiated and released by the locomotive engineer. While subject to many operating disadvantages, these block signals still represent a practical solution of the problems of maintenance and safety. One central hoisting area uses manual signals controlled from a station at the rotary dump; the other uses an automatic block system.

In this latter system, the area is divided into a number of different sections or blocks. The presence

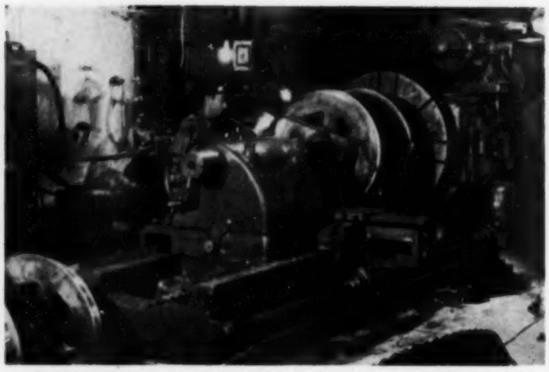

Fig. 9—A 48-in. engine lathe in the No. 17 underground shop machining the drivers for a 15-ton locomotive.

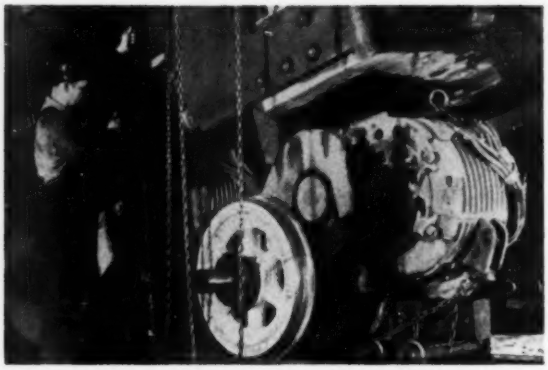

Fig. 10—Removing the motors from a 15-ton Goodman locomotive on one of the No. 17 locomotive pits.

of rolling stock in any block shorts out the block track relay which operates the relays controlling the signal lights for that block and any priority connections which might be set up. In recent years, a semi-automatic system depending on contactors operated by the trolley pole collector shoe has been used to a limited extent.

A few main line locomotives are equipped with radio-telephones for two-way communication. They are single-frequency transceivers powered from the trolley. These sets are used to expedite supplies and facilitate operations in general. They are not a substitute for the signal systems. Areas of about 1-mile radius require little electrical connection. On main haulageways with limits extending about 10 miles, special circuit provisions must be made. A special antenna is installed above the trolley and selectively coupled to it. Booster stations are installed where required. Because of the volume of messages, two frequencies are in use. These cover separate areas which contact only at a central hoisting shaft.

No signal system is any more effective than the enforcement of the regulations governing its usage. In the interests of maximum clarity, operating rules are kept to a minimum. These are based primarily on safety and secondarily on the most economical use of the equipment. Enforcement is implemented by emphasis on cooperation and elimination of hazards rather than by punitive action. All movements are governed by the signal systems with prior arrival the only criterion except in the automatic block area previously mentioned. General methods of operating the equipment are taught during the training period. Then the locomotive engineers of each mine group set up their own operating schedule and procedures subject to the approval of the mine captain.

It may be stated that the chief purpose of the St. Joseph's signal system is the protection of the men. The automatic block signals, the pull-type light signals, the sirens on the locomotives, and even the radio-telephones are designed to warn personnel of the approach or location of a locomotive. The reflector type of tail light is designed to assure the locomotive engineer that his train is still intact and would also be a visible warning to any other locomotive engineer that a loose ore car was on the track ahead of him. The new hinged-type stubby trailer is designed to prevent an ore car from rolling backward. It is strong enough to stop any train and will either derail the cars or plow up ties until it brings the train to a halt, see Fig. 8. A safe haulage system is an efficient one.

Maintenance facilities have had to keep pace with the expanding haulage system. These include repair, overhaul, and redesign, see Fig. 9. This has made it possible repeatedly to adapt existing equipment to meet new demands. Standardization of parts has helped to reduce stock and provide sufficient spares where needed. Armoring and the relocation of controls and connections has not only resulted in improved service and safety conditions, but has also greatly increased the usable rating of the equipment. For example, improvements of the 13-ton class of mine locomotives have increased their capabilities until they not only can pull at least 30 pct more load, but also can stand far more rough service. It is evident that elaborate shop facilities are required to overhaul and to build mine locomotives, see Fig. 10, and other types of heavy mine machinery like the St. Joe shovel. Because of the size of the shafts in this district and the increasing size of mechanical equipment, it was long ago decided to establish the major mine repair shops underground. While each mine group has a small shop for minor assemblies and repairs, the major overhaul, repair, and rebuilding jobs are performed at either the Federal No. 17 underground shop or the Leadwood No. 12 underground shop.

No. 17 Federal Underground Machine Shop: Unlike a surface machine shop which must be housed in a building, this underground shop has almost unlimited space in the old mined-out areas. The average height of the ground is over 15 ft. Since space is not at a premium, this shop continues to spread out. Because the entire area is covered with a maze of track, the handling of supplies does not present a problem. This shop covers over three acres of area, and its normal crew consists of 96 assorted machinists, repairmen, welders, blacksmiths, and electricians. It operates on day shift only. On night shift a few repairmen are always on hand for emergency service.

Acknowledgments

The author gratefully acknowledges the assistance of Walter D. Duffy, Jr., Mine Captain of Federal No. 17; Bert L. Beal, Jr., Electrical Engineer; John J. Northcutt, Mine Engineer; and Theodore O. Seiberling, Bonus and Contract Engineer, in gathering the data for this report. Vincent D. Aubuchon, Assistant Safety Inspector, deserves credit for the photography. Many other members of the staff of the St. Joseph Lead Co. were most helpful with their comments and suggestions.

Earth Resistivity in Groundwater Studies In Illinois

by Merlyn B. Buhle

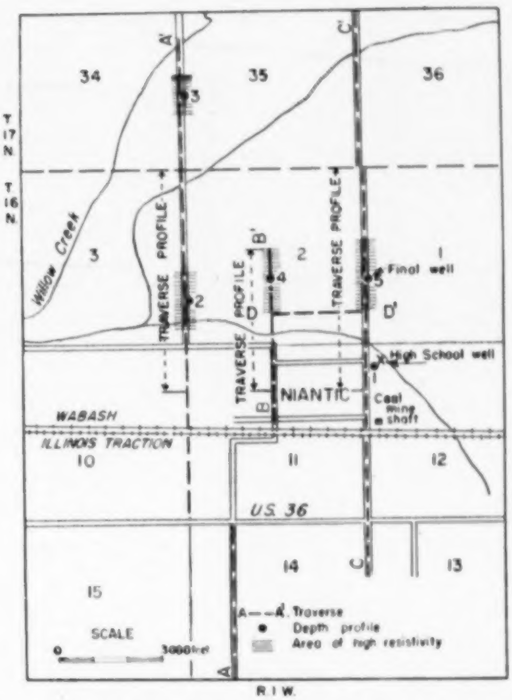

Fig. 1—Map of Niantic area, Macon County, Ill., showing resistivity traverses and areas of high resistivity.

The value of the earth resistivity method in groundwater studies in Illinois has long been recognized. Owing to the sharp electrical contrasts between sand and gravel deposits and glacial till, alluvial silt or underlying shale, much of the earth resistivity prospecting has been of a relatively elementary nature and has been highly successful. Approximately 90 pct of earth resistivity interpretations by the State Geological Survey have been accurate for practical purposes. Four studies involving fairly simple geologic situations are presented in this paper as typical cases.

FOR the past 20 years electrical earth resistivity exploration has been used in Illinois in many phases of study undertaken by the State Geological Survey, chiefly in locating and outlining deposits of water-bearing sand and gravel from which to obtain ground water for municipal and industrial supplies. At least 43 municipalities in the state derive their total water supply from deposits of sand and gravel discovered by resistivity methods. These deposits occur in both Quaternary and preglacial valleys and within much of the glacial drift which covers a large portion of the state.

In recent years there has been much demand from rapidly growing municipalities for help from the Illinois Geological Survey to extend existing well fields. Water supplies for many and varied industries constitute a considerable portion of the Survey's studies. The diminishing need of water supplies for railroads has been accompanied by an increasing demand by the oil industry for water for secondary recovery programs.

The instruments used by the Illinois Geological Survey follow closely the commutated direct current circuits developed by O. H. Gish and W. J. Rooney[1] using the Wenner[2] electrode configuration. More recently replacement of the hand-driven commutator by a synchronous vibrator has led to increased ease of operation and accuracy. Continuing improvement of equipment and technique has led to many changes in the instruments, but the operating theory remains the same.

In the field operation at a selected station, four electrodes are set at equal distances in the ground 6 to 10 in. deep, in a straight line. A 16 to 20-cycle current is applied to the two outside steel electrodes

M. B. BUHLE is Associate Geologist, Illinois State Geological Survey, Urbana, Ill.

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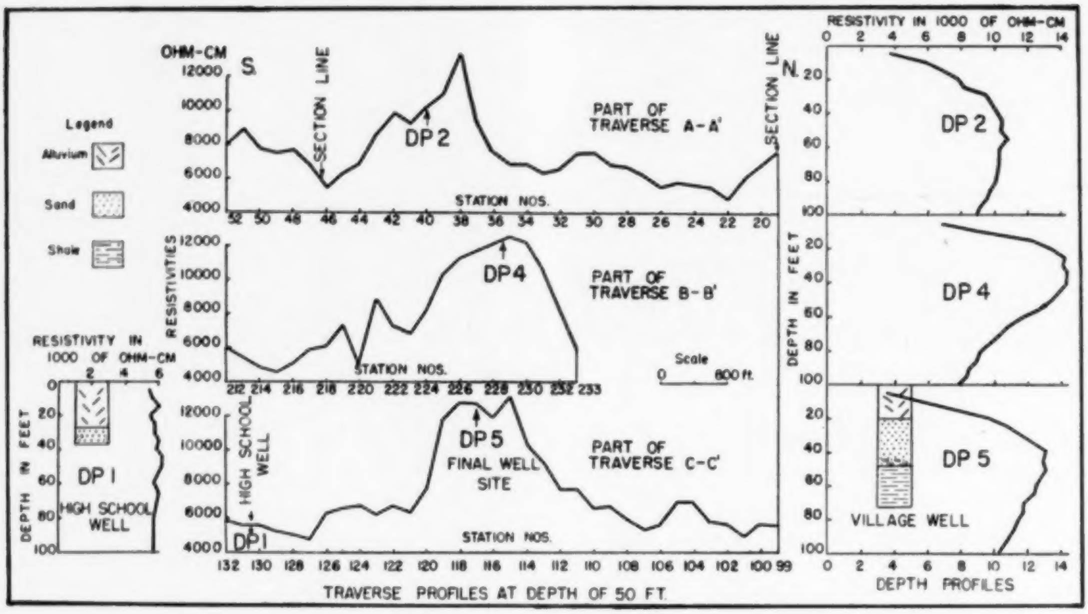
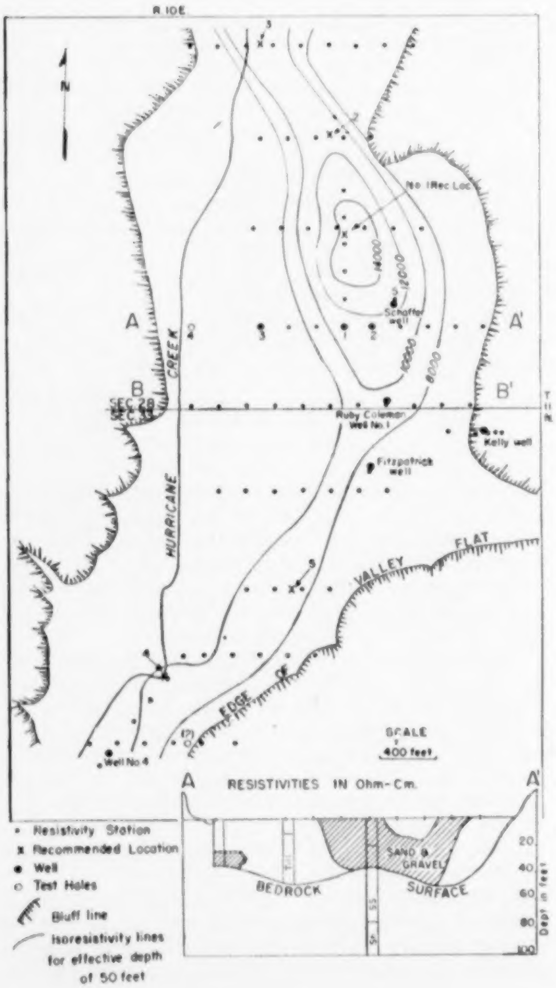


Fig. 2—Resistivity traverse profiles, depth profiles, and well logs in Niantic area.



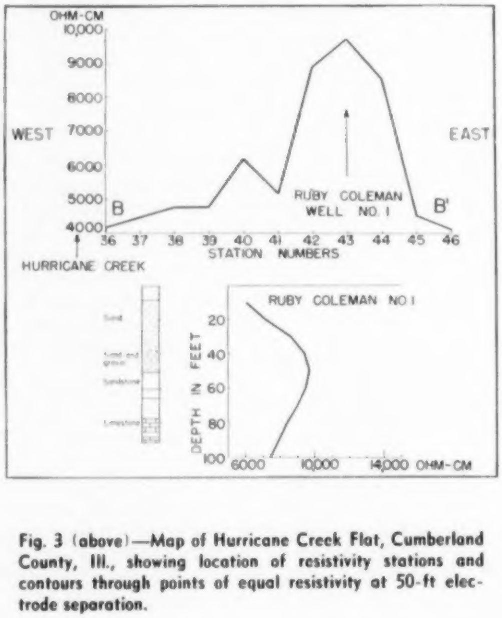


Fig. 3 (above)—Map of Hurricane Creek Flat, Cumberland County, Ill., showing location of resistivity stations and contours through points of equal resistivity at 50-ft electrode separation.

Fig. 4 (left)—Resistivity traverse profile BB', depth profile, and well log on Hurricane Creek Flat.

Fig. 5 (opposite page)—Resistivity traverse profile AA', depth profiles, and well logs on Hurricane Creek Flat.

and a measurement is made of the drop in electrical potential between the two inside copper electrodes. The apparent resistivity is read directly in ohm-cm on a specially calibrated potentiometer. The spacing of electrodes is nearly but not exactly equal to the depth of the earth materials affecting the resistivity. Some geologic situations are well suited to the approach by the step traverse method, by which a single reading at a single electrode spacing is made at each station, while others, more complicated, require depth profiles from a series of readings at each station at different electrode spacings.

For the groundwater work in Illinois, readings are not usually taken to depths much below the surface of the bedrock, since only the glacial drift is usually under investigation. In areas where a mathematical approach to the solution of the problem may be needed, readings are taken to at least twice the estimated depth to bedrock. In areas where the glacial drift is thick, and where a large thick deposit of water-bearing material is sought, stations are usually spaced 1/10 to 1/4 miles apart. In other areas, such as flood plains of streams where elongated deposits of sand and gravel are likely to have abrupt sides, stations are frequently located no more than 100 ft apart.

Approximately 90 pct of the resistivity surveys for water supplies have been made in a 200-mile wide belt running east-west across central Illinois. For the most part this area is underlain by Pennsylvanian rocks, much of which is shale in the upper part. Because shale is usually of lower resistivity than sand and gravel deposits in the glacial drift, an elementary type of resistivity prospecting has been highly successful. Test drilling of recommended sites has proved the interpretation of resistivity measurements to have been correct in about 92 pct of the cases. The methods using type curves and a mathematical approach have been used experimentally in Illinois in fewer than a dozen instances.

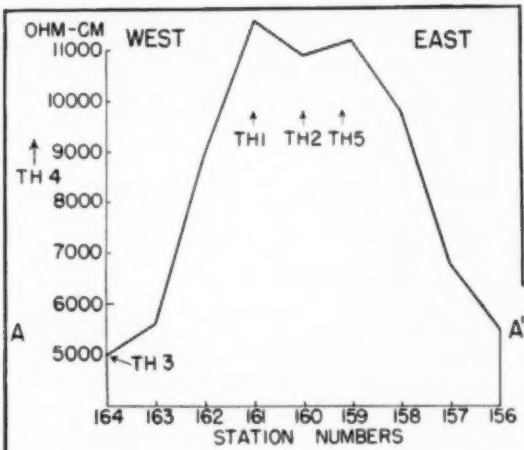
Four specific resistivity studies are presented to illustrate the type of investigation made by the Illinois Geological Survey. Two are studies in which interpretation of the data proved correct, and two are studies in which the interpretation was wrong to some extent.

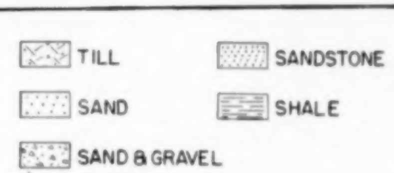
Location of the first study is Niantic, Macon County, in the east-central part of Illinois, on the surface of the Illinoian glacial drift, west of the edge of a moraine of Wisconsin age. The area shown in Fig. 1 is relatively flat and there is no surficial evidence of sand or gravel deposit. A coal mine shaft at the edge of the village leads to extensive workings beneath the village and surrounding area. It was reported to be a dry mine.

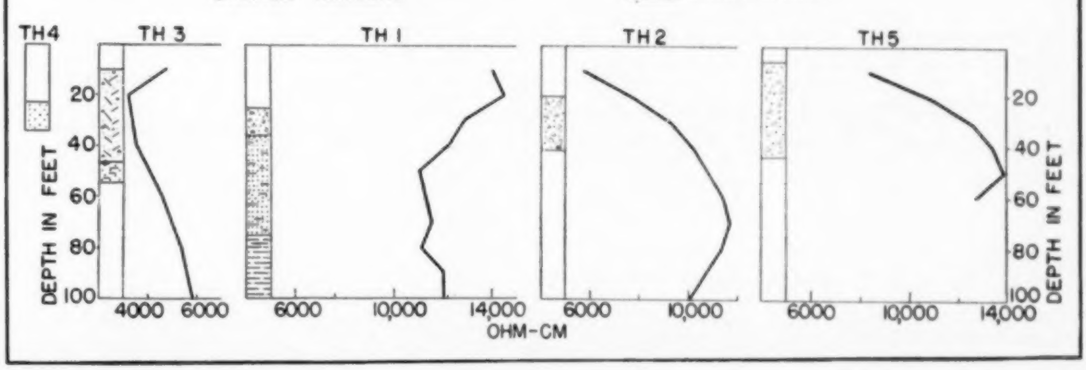
Parts of three resistivity traverses are shown, AA', BB', and CC', extending south to north across the area with stations 200 ft apart. Electrode spacings of 25, 50, and 75 ft were used at each station except at points 1, 2, 3, 4, and 5 where readings were taken at 5-ft intervals to a maximum spacing of 100 ft. The areas of high resistivity as well as the locations of the depth profiles are indicated on the map.

Fig. 2 shows the pertinent data plotted. The conspicuous feature on each of these traverses made at the 50-ft electrode spacing is the localization of the resistivities above 8000 ohm-cm. The geologic conditions found by test drilling at depth profile 5 can be expected to occur also at sites of profiles 2 and 4 where similar curves were obtained. The low flat depth profile near the High School well indicated very little permeable material, which agrees with the log record of the well. A producing well was drilled at the location of depth profile 5 on the basis of the resistivity data. It had a specific capacity of 64 gal per min per ft of drawdown.

Fig. 3 presents the results of a second study, located 6 miles northwest of Casey, Cumberland County, in the southeastern part of Illinois, on the flood plain of Hurricane Creek. In Pleistocene time, a stream flowed in this valley from northeast to







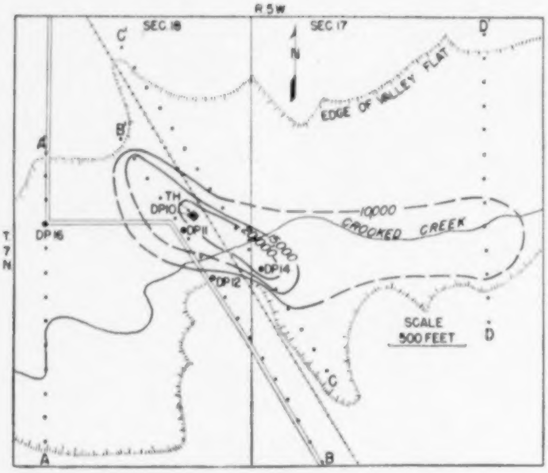


Fig. 6—Map of Crooked Creek Flat, Hancock County, Ill., showing locations of resistivity stations and contours through points of equal resistivity at 100-ft electrode separation.

southwest along the frontal moraine of the Wisconsin ice. The valley contains considerable sand and gravel deposited by the glacial water, but the location of clean portions that are good aquifers is generally unpredictable.

Measurements at all stations on traverses AA' and BB' were taken at the surface to an effective depth of 120 ft by 10-ft intervals. This was done before test holes in the flat revealed no depths to bedrock greater than 50 ft. Later station measurements were taken only to an effective depth of 60 ft. Traverse BB' was run first, and a test hole completed as a producing well, known as the Ruby Coleman No. 1 well, was drilled at a site chosen from the resistivity data. Lines of equal resistivity were drawn as shown by Fig. 3.

Fig. 4 presents resistivities obtained at the 50-ft electrode separation along traverse *BB'*, the resistivity depth profile at the Ruby Coleman well No. 1 site, and the log of test drilling at the site.

Fig. 5 presents the results along traverse AA', taken also at the 50-ft electrode separation, together with numerous test holes drilled along it, and the depth profiles and logs of these test holes. It will be noted that test holes 1, 2, and 5 on traverse AA' and the Ruby Coleman well No. 1 on traverse BB', which were drilled on the resistivity highs, encountered thick sand sections, whereas test holes 3 and 4, which were drilled off the resistivity high, encountered little or no sand. The curves obtained on and off the deposit and resistivity high are vastly different. Additional resistivity measurements were made in the fall of 1951. On the basis of additional information and results of previous test drilling on resistivity highs, recommendations were made for a test drilling program for spring, 1952.

The Ruby Coleman No. 1 and Fitzpatrick wells have been abandoned; well No. 4 was a slotted pipe installation of very low capacity and is rarely pumped. The Kelly well is perched on the valley wall at the edge of a gravel pit. Only the Schaffer and Kelly wells are now in continuous production.

Fig. 6 shows the results of an extensive survey completed a few years ago 2 miles northwest of LaHarpe, Hancock County, near the western border of Illinois. In this region the Pennsylvanian rocks become thin or pinched out, so the bedrock surface may consist of shale or limestone of Mississippian age. In the valley bottom of Crooked Creek a resistivity high was mapped. The valley flat itself, which is everywhere at least ¼-mile wide and lies about 50 ft below the general upland level, is a typically favorable location for a sand and gravel deposit. Some sand and gravel bars are exposed in the creek meanders. Sand at least 10 ft thick is reported to have been encountered when piling was sunk for the railroad bridge at the creek crossing. Few records of wells on the uplands are to be

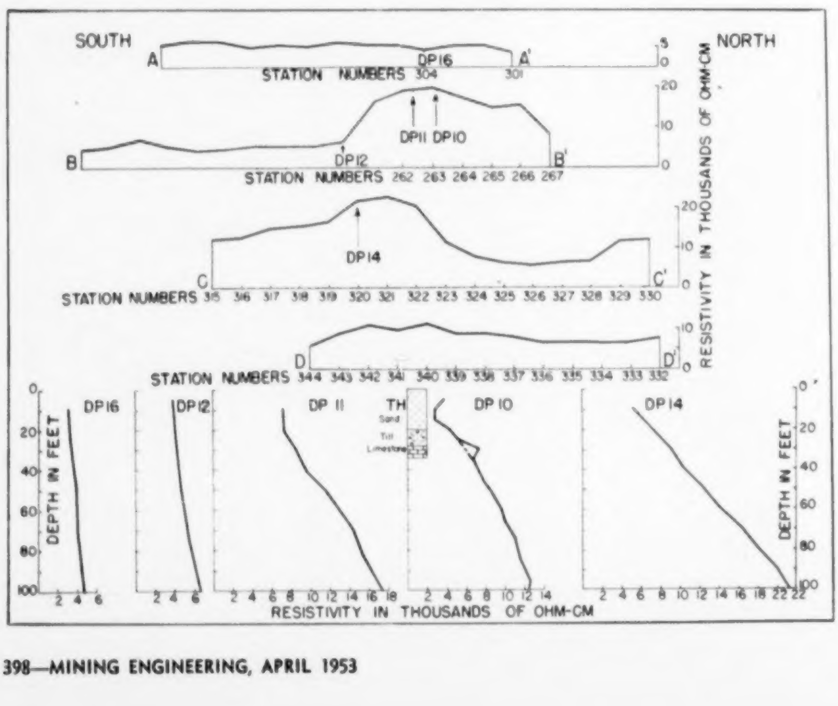


Fig. 7—Resistivity traverse profiles, depth profiles, and well log on Crooked Creek Flat.

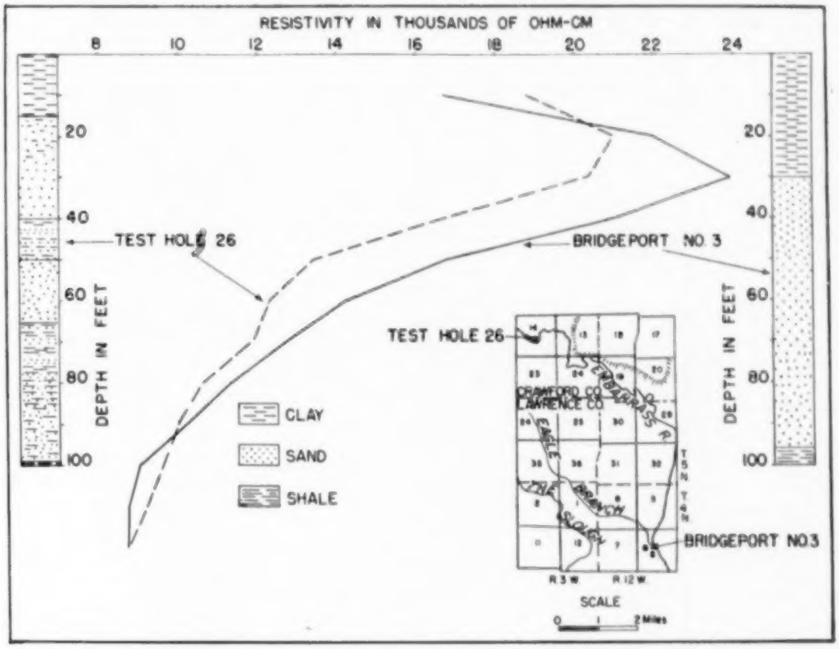


Fig. 8—Part of Embarrass River Flat, Lawrence and Crawford Counties, Illinois, showing resistivity depth profiles, logs of wells, and locations of depth profiles and wells.

found, but those available indicate that the glacial drift may exceed 80 ft in thickness. Four traverses of this survey are shown crossing the flat and extending to the upland on either side. An electrode spacing of 100 ft was used and the stations were spaced at 150-ft intervals. Five depth profiles were obtained, extending from the surface to an effective depth of 100 ft at 5-ft intervals. Lines of equal resistivity were drawn on the basis of these data.

On Fig. 7, traverse AA' shows no resistivity above 5000 ohm-cm, but the other three traverses indicate highly resistant material forming a typical sand and gravel pattern in the creek flat. Depth profiles 16 and 12 were obviously off the resistivity high, whereas depth profiles 11, 10, and 14 are just as obviously on the resistivity high. A test hole, TH, was recommended at the site of depth profile 10. It disclosed 20 ft of sand immediately below the surface, followed by 8 ft of alluvium, which in turn rested on limestone at least 6 ft thick. No well was made at this site because it was believed that there would be insufficient water for the project and because it was obvious that the resistivity pattern was caused by this near-surface limestone.

Fig. 8 presents the results in an area traversed by the Embarrass River in the region lying south of Robinson and Oblong in Crawford and Lawrence counties. The flood plain of this river is many miles wide and relatively flat. In this area the river follows a preglacial channel and is tributary to the Wabash River, which also follows a preglacial channel. The sites of both resistivity stations are on the same river flat, near the Embarrass River itself. The underlying bedrock at both sites is Pennsylvanian shale of low resistivity. It may be inferred that the geologic conditions at both sites are the same.

The Bridgeport No. 3 well had been completed as a Kelly well in a solid sand section 66½ ft thick and produced 1200 gal of water per min with a very slight drawdown. Its production was to be used nearby for water flooding in an oil field. A resistivity curve was obtained close to Bridgeport No. 3 well to check a known good sand section. Later a curve was obtained in the northwest corner of the area shown in Fig. 8 at the site of Test Hole 26 so similar to the curve obtained at Bridgeport No. 3 that drilling seemed warranted.

When Test Hole No. 26 was drilled, however, it was found that although there was a very favorable sand section, some clean and highly permeable, the overall picture indicated low total permeability because of many thin clay laminations and possibly crossbedding. From the fluid-loss record it was estimated that a completed well would produce about 300 gal of water per min. As this amount was inadequate, though a production of 300 gal per min would be very acceptable for many purposes, a well was not drilled.

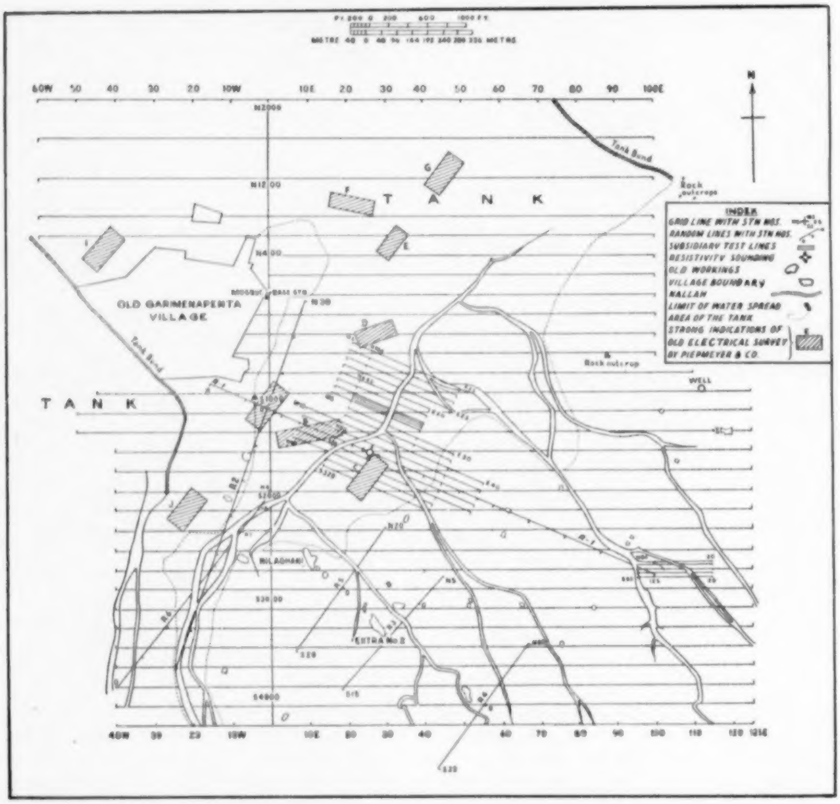
Another test hole, drilled on the Embarrass River flood plain on the basis of a resistivity curve similar to those in Fig. 8, encountered a thick section of clean sand, but there were in addition so many finely divided particles of wood as to preclude the possibility of developing a high production well. Unfortunately it has not been possible to detect the presence or absence of wood in a sand and gravel by resistivity methods.

These studies indicate that resistivity patterns typical for sand and gravel deposits do not always assure that sand and gravel actually occur at depth. However, the percentage of correct interpretations in these groundwater studies is very high. It must be emphasized that a knowledge of local geologic conditions is essential to interpretation of resistivity data.

References

[1] O. H. Gish and W. J. Rooney: Measurement of Resistivity of Large Masses of Undisturbed Earth. *Terrestrial Magnetism* (1925) **30**, pp. 161-188.

[2] Frank Wenner: A Method of Measuring Resistivity in the Earth. *Bull.* U. S. Bur. Standards (1916) **12**, pp. 469-478.



Self-Potential Anomalies Due to Subsurface Water Flow at Garimenapenta, Madras State, India

by M. B. Ramachandra Rao

THE occurrence of copper ores at Garimenapenta, 14° 59 min 30 sec N Lat., 79° 33 min 10 sec E Long., in Nellore district, Madras State, India, has been examined and investigated on numerous occasions during the past two centuries.[1] No tangible orebody was ever located as a result of all the extensive trenching and shafting done in the area by various agencies. However, during 1933 Messrs. Piepmeyer & Co., a German firm engaged by one of the leaseholders of the area, carried out an electrical survey using inductive methods.[2] On the basis of certain strong indications found in their survey, they recommended that the prospect be proved by drilling or shafting. But for want of financial backing no further work was carried out.

When the Madras government more recently proposed investigation, Dr. Krishnan, then Supt. Geologist of the Madras Circle, urged that before further costly ventures were carried out a test geo-

M. B. RAMACHANDRA RAO, Member AIME, is Chief Geophysicist, Geological Survey of India, Calcutta.

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physical survey be made to confirm the reported electrical indications, especially with methods not used by the German geophysicists. This view was endorsed by Mr. Kerr-Cross, mining engineer of the Geological Survey of India. Eventually, from December 1949 to May 1950, a field party led by the present writer made a re-survey of the area, employing self-potential, resistivity, and magnetic methods. A comprehensive account of this survey is shortly being published by the Geological Survey of India. The present paper deals only with some aspects of the self-potential anomalies observed in the locality.

A systematic grid was laid out over an area of 1.3 sq miles, where the old trial pits and shafts exist, as well as the isolated sections examined by Messrs. Piepmeyer & Co. The survey layout is shown on the opposite page. Note that a *tank* is a small reservoir, a *tank bund* the reservoir embankment.

In a considerable part of the area electrical resistivity measurements revealed a highly conductive formation which on closer examination was found to consist of the wet clays of the bed of a small reservoir. These clays occur as superficial deposits, either exposed on the surface or covered up by thin layers of sand. The resistivity of the wet clay is as low as 0.7 meter ohms, whereas resistivity of the adjoining ground, composed of sandy soil and more or less decomposed granitic gneisses, is from 20 to 30 meter ohms. The strong indications found by Piepmeyer & Co. were, in fact, all caused by these highly conductive clays in the tank bed. The inductive method they had employed for their survey must have been extremely sensitive to superficial conductors. The self-potential measurements made by the second field party also revealed no indications which could be ascribed to the existence of any sulphide orebody in depth. It was therefore concluded that no useful purpose could be served by trying to do any further drilling, shafting, or such other costly exploratory work in that area.

During the course of the surveys, self-potentials of +40 to 50 mv strong were noted in the area. These anomalies, which had no relation to the existence of orebodies, were chiefly caused by subsurface movement of ground water in the sands along the beds of narrow creeks in the area and partly by the natural potential difference existing at contact of wet clays and sands. Since this feature was considered to be of some general interest, extensive observations were made in the field and later at headquarters in a series of model experiments to study the nature of these self-potential centers. This paper records the results of such extended observations.

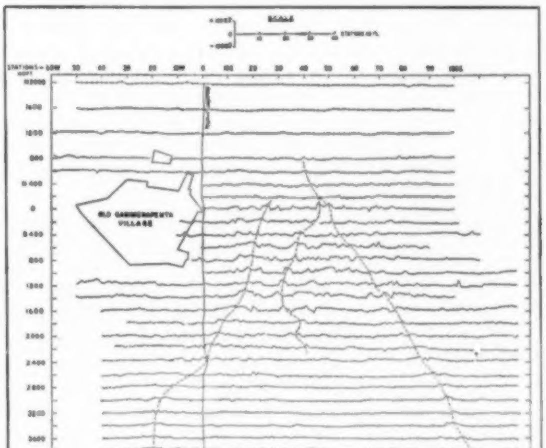

Fig. 1—Self-potential profiles on the grid lines, Garimenapenta.

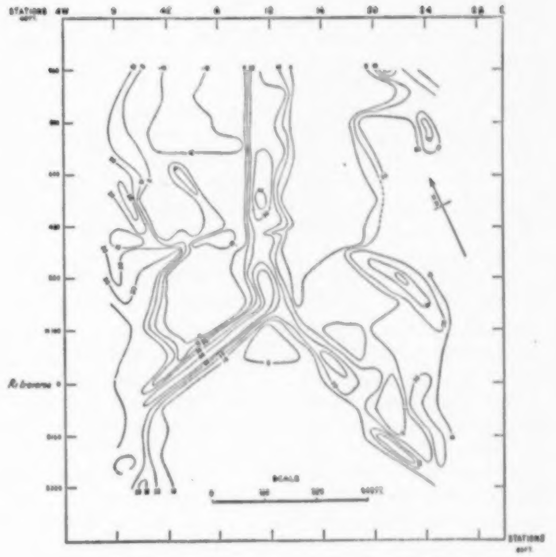

Fig. 2—Equipotential (self-potential) plan, subsidiary grid, Garimenapenta. S.P. contour intervals 10 mv.

Self-potential Anomalies Noted in the Main Grid-Layout

Fig. 1 shows the numerous self-potential profiles obtained over the whole area. The potential difference between the primary base station, kept at 0 station of S 400 profile, and the temporary base point of each line were determined and checked periodically during the surveys to note variations. Fluctuations did not exceed 5 mv. The potential readings were adjusted to the primary base station, the value of which was assumed to be zero.

The feature at once remarkable in all these profiles is the absence of any distinctive negative potentials. A number of zones of positive potential do occur, and the manner in which these narrow zones delineate some prominent gully, or *nullah*, courses is fairly obvious. The two principal zones start from stations 20 W and 110 E, on profile S 4400, and go with N.N.E. and N.N.W. trends respectively. A third zone starting from station 40 E on profile S 2200 goes northward and joins the eastern zone near station 50 on 0 profile. Between profiles S 1600 and 0, especially in the portion coming within stations 10 E to 70 E, there is a swarm of positive potentials on the sands. Further north, after profile N 400, the traverse lines were all entirely in the small reservoir into which water had gone, leaving only the dry silt and clay exposed on the surface.

It may also be noted from the plan of the survey layout that the traverses S 2600, S 3200, and S 3400 cut across some of the most prominent old

workings where the pegmatites had shown copper ores, chiefly malachite. The S.P. profile, however, shows no significant indications in association with any of those old workings. In fact, within the whole area there is no indication of any negative center which could be ascribed to the existence of any mineralized formations or orebody. The only anomalies are the positive potential zones, not more than 50 mv strong, and these are in conformity with the trends of the nullah courses in the area.

Intensive Measurements in the Zones of Positive Potentials

A series of closely spaced lines were laid out in a small portion of the area where the positive potential zones appeared as a pair with a low between them. This small portion is denoted by the short subsidiary lines between main traverses S 600 and S 2200, confined to stations 10 E to 60 E generally, as shown in the layout. S.P. readings were taken on 250 stations and equipotential lines drawn by interpolation. The resulting plan is given in Fig. 2. From this plan it is evident that the positive potentials show definite trends, tracing with remarkable fidelity the pattern of the nullah courses. The way in which the streams at the S.W. and S.E. part of this layout coalesce into one stream at about station 12 on N 160 profile is unmistakably contoured by the strong trends in the equipotential lines.

Other features deserve comment. The streams are only generally indicated, but the magnitude of the potentials are not precisely in conformity with the directions of the flow of water. There are also many minor positive centers scattered here and there which bear no particular relation to the known stream lines.

In the field it was noted that a very thin layer of sand occurs on the surface, while clays occur beneath the sand. The stream beds are marked by a greater thickness of sands, some 2 to 4 ft thick, which are saturated with water and have a resistivity of about 4 meter ohms. The sands in such places are filling up a deeper channel which previously must have been carved out in the clays of the area. In most of the places where the positive self-potential peaks were noted there was no water flowing on the surface, but below a few inches to a foot the ground was saturated with water, and there were distinct trends suggesting lines of subsurface flowage. Several shallow pits were dug out and the potential differences between the clay and sand were measured. Readings taken in the sands gave always a higher value with reference to the base pot embedded in the clay. When the sands were removed and the clay occurring underneath, in depth, was contacted, nearly all the positive potential anomalies disappeared. Furthermore, readings taken after water was bailed out from the pits showed that the flowage of water caused a higher potential opposite the direction in which the water flowed. The sands are fairly coarse and highly permeable. The clay bed at the bottom acts as an impervious layer and the water in the sand flows along a very gentle gradient, in conformity with the channel formed in the clay bed. The free movement of water in the sands under a slight hydrostatic pressure has apparently produced an appreciable electrical potential anomaly.

In a summary of results of the detailed self-potential measurements carried out in the field, two points are important: 1—Between the clay and sands there is a more or less constant electrical relationship, the sands possessing always a higher potential. The magnitude of such potential anomaly is variable but small, not exceeding 20 mv. 2—When the water in the sands, occurring over the clays, has a marked tendency to flow, this potential difference is accentuated, the magnitude going up to 50 mv. The effect of streaming or electrofiltration potentials then becomes preponderant.

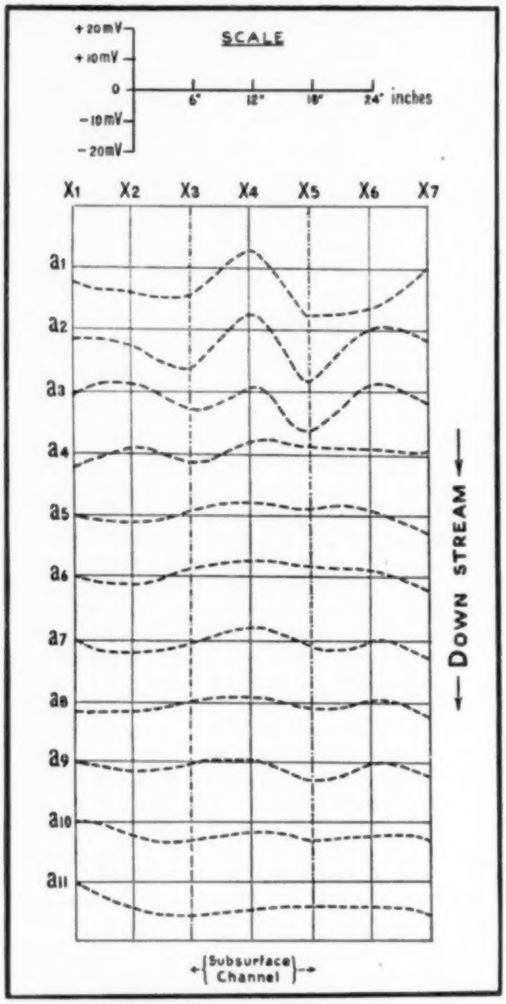

Fig. 3—Self-potential profiles observed in model experiment.

Self-potential anomalies of minor amounts are probably caused by other factors connected with the variations in permeability of the sands and electrical resistivity of the water. These latter factors, however, were not studied, but variations did not appear to be large in the small portion of the area where the intensive self-potential measurements were carried out.

Model Experiments

A series of experiments were carried out in the laboratory at Calcutta by Mr. S. C. Nandi to investigate the nature of the potential anomalies arising from a subsurface flow of water in sand over a clay bed. A large box of wood, 6 ft long, with waterproof lining, was used as a model tank. To simulate the conditions prevailing in Garimenapenta area, the tank was filled with a quantity of fine alluvial

clay covered over uniformly by sand. The thickness and shape of this clay bed were varied for different experiments. In all instances, the clay bed was covered with loose sand, finishing the top surface to a uniform plain level. Water was let in at one end of the tank by means of a controlled fine spray of fresh water from the tap. The subsurface flow of water in the sand depended upon the section and slope of the sandy bed. A suitable outlet for the water at the other end of the tank was also made, although the outlet could not be regulated as nicely as the inlet by fine spraying. On the whole, conditions of experiments simulated the field conditions.

Self-potential measurements carried out in the first series of experiments, with the clay bed having only a plain sloping surface and the sand filled over this clay bed, showed that where the thickness of the sand was small, the potential differences were only +2 or 3 mv, whereas in the portions where the sand was considerably thicker, the readings obtained were +7.0 mv, but anomalies were irregular.

In the second series of experiments, the clay bed had a channel 2 ft wide, and a gentle gradient. The whole of the clay was covered up by sand as in the previous case. With a spray of water giving a constant flow, the potentials measured along profiles, across the channel, distinctly showed a positive reading, but the magnitude was weak and the potential gradient very poor.

In the third series of experiments, a sharp channel, 1 ft wide, with steeper slope, was carved in the clay bed. This was filled with sand, and as usual a constant inlet of water was regulated at one end of the model tank. The self-potential profile obtained is given in Fig. 3. It will be seen, therefore, that in the central portion corresponding to the channel position in the curves a_1, a_2, a_3, a very distinct and characteristic positive anomaly of +20 mv is outlined, faithfully denoting the trend of the channel in which there is a subsurface flow of water. This anomaly in the other profiles is not distinct or readily observable because they happened to be located in the lower reaches of the channel closer to the outlet, where stagnation of water rendered the potential anomaly very weak and indistinct.

Some further experiments were also tried to study the effect of movement of water under different gradients, but no important quantitative results could be achieved, owing to the limitations imposed by the size of the tank and the arrangement for inlet and outlet of water which could not be controlled over a wider range.

Compared to the magnitude of the self-potential anomalies noted at Garimenapenta, the experimental results showed about only half the value. In a qualitative way, however, the model tank experiments showed that a subsurface movement of water flowing through a sand bed gives rise to positive S.P. anomalies, outlining the channel bed along which the water moves.

In the self-potential measurements for well logging, the effects of electro-filtration potentials have been studied in great detail. According to Schlumberger and Leonardon,[3] the magnitude of the *EMF* produced by filtration may be expressed by the equation

$$E = \frac{mRP}{V}$$

where E equals electromotive force, m a constant depending on the nature of the porous medium, R the electrical resistivity, P the pressure, and V the viscosity of the flowing liquid.

It is obvious, therefore, that if the other factors are equal, E would vary directly with the differential hydrostatic pressure of the liquid. The sign of the *EMF* would be such that the electric current it causes to flow would possess the same direction as the liquid in movement.

In well logging the electro-filtration potentials are noted to be a minimum at the boundaries of the porous zone and a maximum in the most permeable section. The magnitude of the electrofiltration potential differences may be of the order of 100 to 200 mv, over a length of a few meters.[4] If the formation is discharging water into the well, the potential anomaly will be positive with respect to an electrode kept at the base station on the surface. On the same analogy, subsurface flow of water in sand under hydrostatic pressure would give rise to potential differences and the anomalies would have a positive sign with respect to points where the hydrostatic pressure is 0. Leonardon[5] has reported that water flowing in the sand of a sea beach would set up self-potentials due to electro-filtration and that water rising by capillarity in a formation would also cause a difference of potential.

Parke A. Dickey[6] has found that natural potentials, as distinguished from electro-filtration and electro-chemical, are observable across the contact of sandstones and shales. He has put forward evidence to show that the potential difference is a specific property of the rock and its contained electrolyte. The cause of these potentials is surmised to be in the relative polar adsorptive capacities of quartz and clay particles.

In Garimenapenta, too, it was observed that the potentials measured on the sandy layers were always positive with respect to clays, but not more than 10 to 20 mv strong, unless of course, the sands were of the nullah bed where there was a subsurface water flow which greatly enhanced the effect, raising the difference up to +50 mv. The S.P. anomalies observed in the Garimenapenta area are therefore to be attributed to a combination of both aspects, such as 1—the natural potential bias, or the existence of an electrical double-layer between sand and clay, and 2—streaming or electro-filtration potentials due to subsurface flow of water.

Acknowledgments

The author would like to express his gratitude to Messrs. M. A. Alwar, S. C. Nandi, and M. L. Chatterjee for their valuable assistance in the field and in the laboratory. Thanks are also due to Mr. Haren Dutta for drawing the illustrations presented in this paper.

References

[1] W. King: *Memoirs*, Geological Survey of India, XVI (1880) p. 185.

[2] O. Keunecke: Geophysikalische Untersuchung eines Kupfervorkommens. *Zeist fur Praktische Geologie*, 13 Jahrg, Marz 1935, Heft 3, pp. 41-45.

[3] C. and M. Schlumberger and E. G. Leonardon: Electrical Coring: a Method of Determining Bottom-hole Data by Electrical Measurements. *Trans.* AIME (1934) **110**, pp. 237-272.

[4] J. J. Jakosky: *Exploration Geophysics*, p. 1039. Trija Publishing Co., Los Angeles, 1949.

[5] Reference 3, p. 288.

[6] Parke A. Dickey: Natural Potentials in Sedimentary Rocks. *Trans.* AIME (1945) **164**, pp. 256-265.

Stream Pollution By Coal Mine Wastes

by Henry F. Hebley

This paper brings within the compass of one comparatively brief article a general description of the situation concerning the nation's water resources. It touches upon the phenomenal growth in the demand for water supply and emphasizes the problems facing the coal industry both with regard to acid mine water drainage discharged from active and abandoned mines and the suspended solids discharged to the stream system from wet coal preparation plants.

IT must always be remembered, with regard to the problem of water-borne industrial wastes, that stream pollution from any cause is just one factor in the comprehensive problem of water supply in modern times. Industries nonexistent 25 years ago are now flourishing, and supplies of water piped to homes and apartments, as well as the greater number of plumbing fixtures per dwelling and per building, have created an ever growing demand on the country's water resources. Indication of this rapid growth in demand is shown in Table I, which is quoted from Abrams.[1]

Table I. Effect of Industrial Expansion on Water Consumption In Various Sections of U.S.A.

Location	Period	Estimated Increase of Population, Pct	Increase Water Consumption, Pct
Baltimore, Md.	1938 to 48	6.0	69*
Baton Rouge, La.	1937 to 45	6.0	78†
Detroit, Mich.	1932 to 45	4.3	47*
Galveston, Texas	1931 to 43	23.0	74†
Houston, Texas	1931 to 43	34.0	61†
Texas City, Texas	1931 to 43	63.5	2500†

* Consumption of municipal supply only.
† Consumption of both the municipal and private industrial supplies.

In commenting on the growing requirements of the State of Texas, the foregoing report states that "between 1890 and 1940 the population of the State of Texas increased 287% and the water consumption 7000 per cent."

The domestic load varies greatly, depending on the extent of the available supply and the habits of the community. According to the report of the President's Water Resources Policy Commission[2] the United States Public Health Service reported a national average of 127 gal per capita per day, varying from 60 gal in communities of 500 persons to 140 or 150 gal in cities of 10,000 or over.

Other critical areas may be cited to illustrate the inter-relation between new industrial processes and the demands for water in the area where the new enterprise is located. Powell and Wilson[3] have pointed out that during World War II, in the vicinity of Louisville, Ky., a rapid expansion of industry took place, consisting of numerous synthetic rubber plants. The demand for water increased from 37 million gal per day in 1937 to 62 million gal in 1943. These heavy requirements drew down the supply stored in the water-bearing aquifers to such an extent that urgent plans for recharging were considered. Similar situations have developed in the Los Angeles area and in the vicinity of Texas City.

Warne[4] has drawn attention to the situation in Los Angeles area, where in the West Basin the withdrawal of ground water in 1945 was 90,000 acre-ft, almost double the amount of the natural fresh water recharge. The draw down has been so severe that the level of the ground water is now below sea level, and sea water is invading the West Basin aquifers at rates up to 300 ft per year.

In the Report of the Engineers Joint Council[5] it is pointed out that in the area of Texas City the ground water table has been critically lowered. In 1930 the daily withdrawal from the water-bearing aquifer was 0.5 million gal. By 1945 the quantity withdrawn

H. F. HEBLEY, Member AIME, is Research Consultant, Pittsburgh Consolidation Coal Co., Inc., Pittsburgh.

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had increased to 23 million gal per day. The level of the water table, therefore, had dropped approximately 150 ft below the sea level. As a result of draining the water-bearing sands, a subsidence of the land surface of 2.4 in. per year has taken place.

One of the most spectacular episodes of water loss brought about by man's activities is described as follows by Foose:[6]

> In the vicinity of Hershey, and in the valley of Spring Creek there were at one time many springs, some of them yielding thousands of gallons per minute. One large spring in particular flowed forth to make several large ponds a few hundred feet east of the plant of the Hershey Chocolate Corporation. One of the reasons for the plant's location was this excellent source of water, known first as the Derry Spring. For more than a century the various springs were used on many of the farms in this area as their only water supply, and for nearly 50 years the Derry Spring has been used by the Hershey Chocolate Corporation. As far as it has been possible to determine, none of the large springs ever went dry, even during the longest droughts.
>
> During the past fifty years many wells were drilled on farms and on properties where new homes were built. Except for very shallow wells, in which the water never stood more than several feet above the bottom of the well, none of these are known to have gone dry. A series of wells were also drilled by the expanding plant of the Hershey Chocolate Corporation. Yields ranged from 200 to 1200 gallons per minute, and a few had no yield at all, demonstrating how poor an aquifer limestone can be "in between the fractures." The Corporation wells continued to have a constant yield in wet and dry season alike, and they never affected in any way the adjacent springs or wells in the valley.
>
> One and a quarter miles southwest of the Hershey Chocolate Corporation is a limestone quarrying operation about 125 feet deep. Relatively little ground water seeps into the quarry; for many years less than 1000 gallons per minute have had to be pumped to maintain operations. One and a half miles northeast of the Corporation is a larger limestone quarry and mining operation whose workings extend more than 400 feet below the surface. Until May, 1946, during normal operations about 3000 to 3500 gallons per minute of ground water were pumped out of the mine. Both of these mining operations remove limestone that is much purer than the average limestone of the valley. As a result there are many openings, large and small, that have been dissolved by water percolating through the rock fractures. Located on this same pure limestone formation is the Derry Spring. The trend of the limestone rocks in northeast-southwest is a nearly straight line connecting the spring and the large mining operation.
>
> During routine mining operations in August, 1946, a blast in the hanging wall of the mine exposed a six-inch wide solution channel about 375 feet below the surface out of which poured an estimated 8,000 to 10,000 gallons of water per minute, flooding the mine in the course of a day. When this occurred nearby wells dried up, ground water seepage into an adjacent quarry ceased, the Derry Spring a mile and a half to the southwest dried up on the second day and two wells of the Hershey Chocolate Corporation were badly affected. After many months of labor the opening in the mine was sealed off with a large steel plate, the adjacent wells had water in them again, the flow of the Derry Spring was restored, and the Corporation wells were again normal.

Van Tuyl[7] has described an interesting situation regarding the influence of air conditioning and modern water uses on the water withdrawals from the aquifer underlying Pittsburgh. The strata are very permeable sands and gravels, deposited during the glacial age, and permit a rapid flow through the deposit. The storage capacity is, however, limited in extent, being approximately 800 million gal. The demand for cooling water has increased steadily since 1927, until at the present time it is double the quantity used in that year. The average withdrawal on a summer day has reached 10 million gal, which indicates a supply for only 80 days. Fortunately the recharge to the aquifer is continuous, although during the summer the draw down is from 8 to 10 ft. During winter, because of the proximity of the rivers and the ease of ground water flow, the water table is returned. The demand for water reaches a maximum in July and August, amounting to 25 pct of the total yearly volume of water pumped. During this period the demands for air condition equal the requirements of all other uses. In fact, the demands on the water resources of the aquifer have reached the maximum rate of recharge, and a further increase in water requirements cannot be satisfied from the present wells without artificial recharge. Natural recharge is limited by the prevention of rainfall soaking through the large percentage of the area of the triangle that is artificially impermeable by street paving, buildings, and parking lots.

Another notable man-made barrier is the sheet piling used to form the embankment along the Allegheny River. This wall, which is 3750 ft long and averages 33 ft deep, reduces the cross-sectional flow area into the aquifer to approximately 50 pct.

During the threatened water famine the metropolitan area of New York suffered an acute crisis, which taught the population in a most spectacular manner how dependent the individual and the community are on water in this present civilization. London, the site of which was selected by the ancient Britons because it was underlain with a porous gravel deposit providing a continuous source of water, has also in recent years been concerned with the lowering of the water table.

Table II. Typical Interstate Agreements for Control of Water Resources

COMPACT	STATES INVOLVED
The Interstate Commission on the Delaware River Basin (INCODEL)	Pennsylvania; New York; New Jersey; Delaware
The Interstate Commission on the Potomac River Basin	Pennsylvania; Maryland; West Virginia; Virginia; District of Columbia; USA U.S. Public Health Service, Office of Army Engineers
The Ohio River Valley Water Sanitation Commission	New York; Pennsylvania; Virginia; West Virginia; Ohio; Kentucky; Indiana; Illinois

With these examples before the country, it is natural that all branches of government are taking a great interest in the conservation of water resources. The comprehensive report of the President's Water Resources Policy Commission[8] is evidence of this concern at the Federal Government level.

There are many aspects of the problem, some in conflict with others: flood control, power generation, land reclamation, domestic and industrial water supply, water shed management, inland and tidal waterways, and stream pollution control. To balance these various factors will tax the combined skills of the country's outstanding engineers and economists.

Because the approach to the problem in many cases lies within the area contained in the drainage basin of the stream system, which never follows political boundary lines, interstate compacts have been adopted to facilitate the control of the water resources within the drainage area. Typical agreements are listed in Table II.

All commissions have been carrying out engineering and economic studies on which to base proposals for a well balanced project of water conservation and control in each of the drainage basins.

Recently, the proposed Incodel Interstate Water Project was made public.[8] Briefly, it calls for the construction of a series of four reservoirs in the upper reaches of the Delaware River watershed. It will provide satisfactory sources of water for the areas that require it, and it will also provide an increase in the flow of the Delaware River during the dry months of summer and autumn. The salient features of the project are given in Table III.

Table III. Apportionment of Water Supply Under Proposed Incodel Interstate Water Project

Purpose	Million Gallons
Total reservoir storage capacity	527
Recreational use (boating, fishing, etc.)	111
Water supply to New York and northern New Jersey	100
Stream flow regulation and future water supply to Philadelphia and southern New Jersey	316

Because of the widespread demands, severe competition has developed between states, between communities, and between individuals, necessitating priorities for the use of water. Highest priority is assigned to water supplies for municipal and domestic purposes. All other factors must be modified to maintain the necessary standard of priority. It is this strict insistence on water purity for the protection of public health that has impelled industry to install equipment for the treatment of its water-borne trade wastes. Roughly, such wastes can be divided into two kinds, organic and inorganic. Typical of the former are the wastes arising from packing houses, food processing plants, pulp and paper mills, cheese and butter factories, and the beet sugar industry. The inorganic trade wastes include the pickle liquor from the steel industry, brines from various wells, acid water drainage from coal mines, and liquid wastes from the metal-finishing industry. Two other great sources of pollution are domestic sewage from centers of population, and solids eroded from the soil by action of annual rainfall run-off.

As mentioned previously, there is always some interaction between wastes discharged into the stream system. An interesting example given by Beal and Braley[9] indicates the reluctance of communities to correct a situation until faced with a crisis:

> There is a city not far from Pittsburgh that uses an open creek in lieu of a trunk sewer. The drainage from three large mines, ranging in volume according to season from four to seven million gallons daily, is also pumped into this creek. It is only the acidity of this mine drainage that inhibits putrefaction of the sewage. Now, with the possibility in the offing that mine pumping will be stopped, the city government is considering buying or leasing those abandoned workings in order that it may continue to add that acid water to the city's sewage, as a prophylactic, pending the time when the city government can complete a modern sewage disposal plant.

This commingling of sewage and mine drainage takes care of the area immediately surrounding this city just as other industrial wastes have their inhibiting effect on other cities' sewage. But as these streams flow on they receive other streams, often naturally akaline, so that dilution and neutralization soon reduce the bactericidal and bacteriostatic effects of these industrial wastes. Because of this neutralization, new infection in the stream permits a resumption of sewage decomposition in areas that should be clean. Therefore, we may be sure that problems involved in the treatment of water-borne industrial wastes, rolling up like a snowball, are going to be among the tremendously important industrial problems of the next decade.

Biological Oxygen Demand

As pointed out by Eldridge[10] the contamination of a stream by organic wastes arises from decomposition of those wastes through the action of bacteria. In consuming this organic material, the bacteria combine it with oxygen to maintain their life processes. This is *biological decomposition*. It is generally held that *anaerobic* bacteria carry out their work in the absence of oxygen. But as Eldridge has observed, these bacteria obtain their necessary oxygen from the organic compounds which are composed of such elements as oxygen, nitrogen, carbon, sulphur, and hydrogen. The removal of oxygen leaves elements that form compounds containing no oxygen, such as ammonia and hydrogen sulphide. These compounds have characteristic foul odors. When a body of water is dominated by such anaerobic decomposition, the aquatic life of the lake or stream is destroyed because of the toxicity of the compounds. If there is an ample supply of elemental oxygen present in the body of water, *aerobic* bacteria continue the work of decomposition to yield end products such as sulphates, nitrates, water, and carbon dioxide. The foul-smelling products created by the *anaerobic* decomposition are oxidized and are harmless. Thus the oxygen contained in the stream or lake is the most important factor in disposing of organic pollution discharged to the stream system. Where oxygen is not present in sufficient quantities to complete the decomposition of organic wastes, the stream waters may be completely depleted of oxygen, whereupon the stream will become septic.

This demand for oxygen for the decomposition of organic by biochemical processes has resulted in a measure of pollution universally employed by sanitary engineers. It is known as the Biochemical Oxygen Demand, or abbreviated, B.O.D. It is defined by Phelps[11] as "the oxygen that will be demanded by the material in the course of its complete oxidation biochemically. It is not at all related to the complete oxygen requirements in chemical combustion, but is determined wholly by the availability of the material as a bacterial food and by the amount of oxygen utilized by the bacteria during its oxidation." This measure, while of great importance to such enterprises as the food processing industries, pulp and paper mills, tanneries, creameries, and domestic sewage disposal works, does not apply to such inorganic wastes as acid water drainage from coal mines and suspended solids contained in the water discharged from coal preparation plants. However, it is of interest to note that in one set of standards the measure of B.O.D. was to be applied to all wastes. That requirement has been changed.

Stream pollution created by the coal industry

stems from two main sources, acid water drainage from mines and suspended solids discharged with the effluent from coal preparation plants.

Acid Mine Drainage

The acid mine water problem has been subjected to intensive research for years, and the investigations are continuing at Mellon Institute, West Virginia University, and Johns Hopkins University. It is surrounded with great difficulties, not the least of which are the stupendous volumes of water that must be handled.

According to Supplement C of the Ohio River Pollution Survey,[12] the total estimated mine acid load delivered to the Ohio River Drainage Basin was approximately 2,500,000 tons per year, a figure derived from the data collected in 1940. Since that time numerous mines have been worked out and abandoned and new operations started. The measure of confidence that can be placed in the figure, therefore, is not known, but it will serve to indicate the magnitude of the problem.

In the Mellon Institute *Survey of Mine Drainage,*[13] Dr. S. A. Braley points out:

> In general, acid mine drainage consists of a solution of iron, aluminum, calcium and magnesium sulphates. The iron and aluminum sulphates react with water to give an acid solution, whereas the calcium and magnesium sulphates contribute to the hardness. The acid coming from the iron and aluminum sulphates, neutralizes the natural alkalinity of the stream receiving the drainage.
>
> The iron in the drainage may cause the receiving stream to become very turbid with iron hydroxide or, depending on the concentration of iron sulphates in the drainage, may result in a red water where the iron remains dissolved in the highly acid solution.

The mine drainage in western Pennsylvania, West Virginia, Ohio, and Kentucky, where many of the mines are shallow, is greatly affected by rainfall. Results shown in Table IV are taken from a study made by Carpenter and Herndon of mines located on the water sheds of the Monongahela and Cheat Rivers.[14] The average cover over most of these mines varied from 100 to 300 ft. Braley[15] in his work on mine acid drainage at Mellon Institute has noted a similar occurrence. In mines having shallow cover, the changes in the rate of drainage flow are closely parallel to the flow of the surface streams of the neighborhood, but the flow variation becomes more uniform as the depth of cover increases. Unfortunately, the greatest difficulty is experienced in the mines that have shallow cover, especially if their discharge is above the stream level, as the drainage ultimately reaches the water shed.

Table IV. Effect of Rainfall on Mine Drainage in Monongahela and Cheat River Area

Year	Gal Per Day Per Acre of Mined Out Area	Remarks
1928 to 1929	1000	Normal
1929 to 1930	500	Drought latter 1929, entire year 1930
1931	660	Normal

In abandoned shallow cover drift mines, the fluctuation of flow can vary as greatly as 25 to 1 in a few days and a ratio of 6 to 1 in volume of water can take place in a few hours. For example, following a heavy rainfall the flow was observed to rise from 50,000 to 700,000 gal per day in 4 hr, a ratio of 12.7 to 1. To design any kind of treatment that would automatically adjust itself to such a wide range would tax engineering ability to the utmost. Economically it would not be feasible, and in the case of abandoned mines it is out of the question. Yet the greatest volume of acid water discharge is from such mines.

A comment may be made here regarding the use of the pH measure in the study of acid mine drainage. Carpenter and Herndon[14] and Braley[15] all noted that in some cases the pH value of the stream does not rise after dilution with the alkaline waters from tributary streams. That is true for most of the acid mine discharges in western Pennsylvania and northern West Virginia. A buffering action seems to take place at an approximate pH value of 3.0 that permits appreciable quantities of alkali to be added to the acid solutions, without raising the pH. Selections from Table III in Carpenter and Herndon,[14] shown here in Table V, indicate this action. The samples were taken in northern West Virginia. Because of the existence of buffering action those investigating acid mine water problems are aware that the pH value may lead to false conclusions. That is not to say, however, that the pH value is not useful. It is generally determined and reported. It represents the hydrogen ion concentration at an equilibrium depending upon concentration and temperature, and is not a measure of the titratable acidity. The acidity of acid mine drainage is the result of the hydrolysis of the iron and aluminum salts into free acid and hydroxides and/or basic sulphates, and the total titratable acidity is the result of their complete hydrolysis.

Table V. Relation Between Dilution and pH Value

Sample No.	6	7	8	11	12
Initial Acidity in P.P.M.	1200	3600	920	950	7100
Ratio of Dilution			pH Values		
0	3.0	3.0	3.0	3.0	3.0
1 to 1	3.0	3.0	3.0	3.0	3.0
1 to 2	3.1	3.0		3.0	
1 to 5	3.2	3.0	3.2	3.3	3.0
1 to 10		3.0	3.2	3.3	3.0
1 to 20		3.0	3.8		
1 to 30					
1 to 40					
1 to 50	3.6	3.5	4.2	4.2	3.0
1 to 100	4.0	3.5	4.9	5.0	3.8
1 to 200	4.4	3.8	5.5		
1 to 400					

During their studies of the forms in which sulphur occurs in coal, Parr and Powell[16] indicated that bacterial action by some of the sulphur-producing organisms might possibly explain some of the high acidities found in mine waste waters. Investigation of this possibility was carried on by Hinkle and Koehler[17] at West Virginia University through the employment of bacteriological techniques. Two micro-organisms have been isolated that are thought to have a part in promoting the formation of acid. One of these, Thiobacillus Thiooxidans, converts elemental sulphur or sodium thiosulphate to sulphuric acid. Further study is being carried on to determine the reasons for the rapid formation of acid in abandoned mines compared to those in operation. In so far as the investigations have been carried on, these micro-organisms have not been found in alkaline mine waters.

The other organism seems to be a factor in the oxidation of ferrous sulphate to ferric sulphate with the subsequent hydrolysis to ferric hydroxide.

Temple and Colmer,[18] in continuing the work at West Virginia University, showed that the oxidation of ferrous iron in acid water to produce the characteristic red color was a bacteriological process and not one of simple atmospheric oxidation. They suggested that the bacterium be designated as Thiobacillus Ferrooxidans.

This phase of research is still subject to discussion and consideration by the various investigators as the work proceeds. Leathen and Braley[9] have investigated this aspect of the problem independently and have commented as follows:

> Both sulfur and iron oxidizing bacteria have been isolated from all of the acid mine waters examined. The sulfur oxidizing bacterium has been identified as *Thiobacillus thiooxidans*, and oxidizes elemental sulfur to sulfuric acid. One statement has been found in the literature to the effect that *Thiobacillus thiooxidans* may oxidize sulfide sulfur, but that this has not been confirmed experimentally. It is believed that Mellon Institute may properly be credited with providing some experimental evidence that this organism does not oxidize sulfide sulfur, at least as it occurs in the coal measures. For, in the experiments, when graded sulfur-ball material replaced elemental sulfur in the substrates, and the substrates were inoculated with the microorganism, the normal, chemical rate of acid formation was not enhanced. Inoculation of media, containing museum grade pyrite, also, was not oxidized by these bacteria. Inoculated substrates containing museum grade marcasite, however, indicated a slight increase in acid formation which could be attributed to *Thiobacillus thiooxidans*. It is not felt that appreciable formation of acid in a mine can be attributed to this microorganism, as the sulfuritic material, "sulfur-ball", usually found in bituminous coal seams and associated rock strata are not oxidized by any of the strains of *Thiobacillus thiooxidans* used in our studies.
>
> The iron oxidizing bacteria, which this Institute is refraining from classifying until the physiological studies are completed, have caused three to five fold increases in the amount of acid formed from sulfur-ball material and from marcasite. Museum grade pyrite was not attacked. At the present time, the amount of acid produced from sulfuritic materials by this microorganism in nature is unknown, and cannot be differentiated from that produced by strictly chemical reactions.
>
> Recently, Dr. Jay V. Beck, Brigham Young University, has written that he has been able to demonstrate that our cultures, as well as some he obtained from Bingham Canyon, Utah, were "... able to convert iron pyrite to soluble iron with a decrease in pH." This observation confirms some of our work.
>
> It is suggested that the role of the iron oxidizing bacteria in acid production may be as follows: the speed of atmospheric oxidation of the iron sulfides seems to vary directly as the available surface, the amorphous sulfur ball oxidizing with much greater rapidity than the densely crystalline pyrite. Ferrous sulfate, the product of the first atmospheric oxidation, is in chemical equilibrium with the sulfides. The iron oxidizing bacteria then oxidize ferrous sulfate to ferric sulfate, which, in contact with sulfur ball material, oxidizes the latter to ferrous sulfate while the ferric sulfate is in turn reduced to ferrous sulfate. This increased quantity of ferrous sulfate now undergoes bacterial oxidation, and the cycle repeats and repeats in the manner of an expanding spiral.
>
> The iron oxidizing bacteria, however, should not be considered wholly detrimental in nature, but are of assistance in the deposition of ferric sulfate in streams, outside of the mine. It has been determined that concentrations of ferrous iron, oxidized only 48 percent by a strictly chemical reaction in two years, were completely oxidized by these bacteria in eight days. Such oxidations are advantageous.

The iron oxidizing bacteria, by greatly increasing the rate of oxidation, induces the deposition of basic ferric sulfate, 'yellow boy', in the shortest possible distance in the stream, confining an unsightly condition to the smallest possible area. Furthermore, it greatly assists the stream to make a very rapid recovery as far as dissolved oxygen is concerned. Dissolved oxygen is essential to all aquatic life, both plant and animal. When acid, ferrous-iron-bearing, waters enter a normal stream, the dissolved oxygen is practically depleted owing to the amount required to transfer the ferrous iron to the ferric state. If this were to take place at the slow chemical rate of oxidation, whole streams, or at least huge portions of them, would be void of all life. When the oxidation rate is increased several fold by the activity of the bacteria, this area, depleted of oxygen and void of aquatic life, is confined to the smallest possible section of the stream. The stream, then, has an opportunity to absorb atmospheric oxygen to replenish its supply. Making a rapid recovery, the stream can again support an abundance of both plant and animal life in a short distance from where the ferrugenious water entered. The organism, in this respect, is of distinct value in nature.

It is frequently stated by many who have only given cursory thought and consideration that the problem can readily be solved by neutralizing with lime. In all probability, this method of attacking such a situation stems from the installation at the Calumet Mine of the H. C. Frick Coal Co. It was installed in 1914 during World War I to produce certain specific products for gas purification that were unavailable from Germany at the time. A description of the plant is given by L. D. Tracy in the Transactions of the AIME in 1921.[19] It was abandoned immediately after the War.

To ascertain the feasibility of lime treating acid mine water, the Pennsylvania Sanitary Water Board authorized the Mellon Institute to carry out research on lime in its various forms. The following conclusions were based on the aforementioned research. They are published in a report issued by the Pennsylvania Sanitary Water Board, Department of Health, Commonwealth of Pennsylvania:[20]

1. Although acid mine drainage can be chemically treated with lime or other alkalies to neutralize the acid, such a method is not practical or feasible because of the economic and other difficulties involved.
2. The use of limestone or hydrated lime to neutralize acid mine drainage produces hard water.
3. A neutralizing treatment would be effective only if the plant were designed and staffed to treat the maximum seasonal flows and the large fluctuations caused by natural conditions.
4. After completion of mining operations on a property, continuation of the treatment indefinitely would be required.
5. The findings of the Mellon Institute Fellowship program to date show that the water that enters a mine through rock and earth strata is normal ground water, free from acid. From these results, it seems quite evident that the only hope of preventing the flow of acid drainage from a mine is by:
   a. Stopping the formation of acid from sulphuritic material on the walls and roof, or—
   b. causing the water entering the mine to

leave the mine by the shortest possible route and quickest possible time without leaching the acidic substances so formed from the walls and roof, or—

c. diverting all water from the mine. The Fellowship referred to has no confidence in any proposal to neutralize continuously the acid mine water flowing from a coal mine in Western Pennsylvania.

6. Notwithstanding the impracticability of the suggested limestone or lime treatments for continuous flow of acid drainage from mines, hydrated lime might be used successfully to neutralize casual pools of acid water found in coal workings.

In regard to the practicability of using limestone or hydrated lime, theoretically, it would require approximately 1 ton of lime to neutralize 1 ton of sulphuric acid in acid mine water. It would require a large excess of lime to complete the reaction in a reasonable time.

In regard to the availability of lime to treat these acid waters, statistics from the Minerals Year Book, 1944,[21] may be of interest, see Table VI. According to Supplement C of the Ohio River Pollution Survey[12] the acid load discharged into the Ohio River streams system from Pennsylvania approximates 889,000 tons per year. Possibly it would take all the lime that Pennsylvania produces to treat the situation. Even should there be sufficient lime to treat the acid drainage, the oxides of iron would separate as a watery gelatinous sludge which settles very slowly. If this material were to be settled before the treated drainage was discharged to the stream system, very extensive lagooning acreage would be required. In hilly terrain, similar to western Pennsylvania, West Virginia, and East Kentucky, such lagooning would present great difficulty. From time to time, such settling basins would have to be cleaned out. That poses the extremely difficult problem of disposal.

Table VI. Availability of Lime

Year	Market	Tons
1944	U.S.A. production *open market* and *captive*	6,473,563
1944	U.S.A. Total *open market-captive-chemical plants*	8,954,183
1944	Penna. Production Agric.-Bldg.-Ind.-Chem.-Refr.	1,026,292

Some study was made to ascertain if a market could be found in the paint industry for the ferric oxide, or rouge, but the results were not promising. On the other hand, if the material were deposited on the adjacent hills, the 36-in. annual rainfall would wash the sludge back into the stream system. There is another result of such a lime treatment. In the reactions that neutralize the acid, the iron in the acid mine water is replaced by calcium and all the sulphate originally present remains in solution as calcium sulphate. This material imparts permanent hardness to the water.

In the anthracite field considerable trouble is experienced with acid drainage water, and in many cases where a percentage of the volume pumped is diverted for use in the coal preparation plant or breaker the water is treated with lime for neutralization before use in the breaker equipment.

The problem of corrosion of equipment is in some cases very severe. As a result many of the companies have resorted to the use of acid-resistant metals and extra heavy dimensions in the design of the pumps, valves, and piping.

According to Ash,[22] the treatment of acid mine water for the coal cleaning plant through the use of lime has been in practice since 1932. A concentrated lime water mixture or slurry is fed either into the breaker water supply reservoir or into the pumping system. High calcium lime + 90 pct CaO, magnesium lime, MgO 5 to 25 pct, dolomitic limes, MgO 25 to 45 pct, and hydrated lime, $Ca(OH)_2$ are used. The rates of reaction of high calcium hydrated lime and of dolomitic lime are rapid. Sulphuric acid, however, forms insoluble calcium sulphate and this retards the reaction. With the dolomite magnesium sulphate is formed and is more soluble in water.

It must always be borne in mind that in the anthracite field of Pennsylvania, the amount of water that must be removed from the operations is extremely great, averaging 30 to 40 tons per ton of coal produced. As Griffith[23] has pointed out, although the average rainfall in the region has not altered, the amount of water entering the mines through breakage of the overlying strata to the surface is continually increasing. An example is given in Table VII of one of the larger operations in the northern anthracite field.

Table VII. Water Removal in Typical Anthracite Mining Operation

Years	Ratio, Tons of Water Pumped to Tons of Coal Produced
1920	8.4 to 1
1925	10.6 to 1
1930	11.4 to 1
1935	26.2 to 1
1940	32.7 to 1
1942	30.3 to 1

The difficult aspect of the problem is to make provision for controlling the drainage of abandoned or inoperative mines. Of the total volume pumped, 66 pct is discharged from the aforementioned class of properties. Under such conditions, with the economic factors involved, comprehensive planning is needed for the handling of the water of the whole anthracite region. Investigations are being carried out. One method seems the most feasible, i.e., a tunnel system arranged for draining by gravity those reservoirs that lie above the tunnel outlet and lifting mechanically the water lying below the outlet. The plans must be long range, however, as the number of inoperative and abandoned mines are on the increase. However, it should be remembered that the volume of drainage from the anthracite region, 730 sec ft, is great enough to affect the volume of flow in the surface stream system, if it is removed. It is a phase that must be taken into account.

The Suspended Solids in Washery Waters

Although at the present time "no practicable method of removing the acid properties of mine drainage is known," as Felegy, Johnson, and Westfield point out,[24] there are some methods that can be employed for the treatment of suspended solids from water discharged to the stream system from coal preparation plants. The problem of suspended solids is the second major difficulty facing the coal industry in the control of stream pollution.

The silt problem created by the anthracite industry from water discharged from the breakers has been one of long standing, and it is only in recent years, with the cooperation of the Department of Engineering of the Pennsylvania Department of

Health, that the removal of suspended solids has progressed.

The water clarification systems of various coal preparation plants have been described in detail in numerous articles, and as each one has been designed to meet the individual needs of the particular plant, no attempt will be made in this paper to cover them. Nearly all the systems employ some or all of the following equipment.

In elevated settling cones the suspended solids settle toward the apex and are drawn off as a thickened slurry or sludge, while the clarified water overflows at the surface into a launder around the periphery to a discharge funnel. There are no moving parts. Gravity and the hydrostatic head are depended on to maintain the flow of the thickened sludge.

Drag conveyor settling tanks are equipped with a slow moving scraper conveyor that drags along the bottom of the tank, then up an incline to a lip at the end of the tank. The settled material is thus removed from the tank, while the clarified water is discharged into a sump.

Dorr thickeners are generally circular in shape with a conical bottom sloping gently toward the center. A series of ploughs attached to a rotating supporting structure moves the settled sludge spiral fashion toward the center of the apparatus. The sludge is then withdrawn in its thickened state through special pumps. The clarified water overflows the launder constructed around the circumference of the unit, which is quite flexible.

Dependent on the rate of operation, this equipment may be used as a classifier removing the coarser particles, as an underflow, and overflowing the finer particles with the water into the launder.

Hydraulic cyclones developed by the Dutch coal industry in Holland have recently been applied to the clarification of washery water. This equipment, which also acts as a fine coal cleaning unit, has many applications.

For the further dewatering of the thickened sludge, centrifuges, vacuum filters, and thermal dryers are employed. The necessary pumps and piping, of course, form part of the system.

Finally, at many coal preparation plants, some or all of the water overflow from the clarification system is discharged to settling ponds or lagoons for a long period of retention prior to being discharged to the stream system. In some instances such settling basins may be cleaned out periodically, while in others the acreage and storage capacity are great enough to serve for years.

It is safe to say that with the growing demand for a reduction in the quantity of suspended solids in the washery effluent, greater care and thought must be given to the design, and more elaborate equipment will have to be installed. In passing, it may be said that the designer is not entirely responsible for the inability of the clarification system to remove sufficient solids. If the plant is designed for a stipulated capacity, and the owner increases the feed appreciably, it is virtually certain that the settling system will be overloaded. Another factor is the cost of the plant. The initial design may have provided ample equipment to yield a satisfactory effluent. However, when the estimate of cost is received, there is an immediate request for a revision of the estimate downwards. Such revisions result in the removal of some equipment from the design.

In the future, greater attention will have to be paid both by the designer of plants and the coal operator to the requirements of the regulatory bodies having control of stream pollution. At the present time there is under consideration a tentative suggestion from the Pennsylvania Department of Public Health regarding the amount of suspended solids discharged to the stream system from coal cleaning plants. It is realized that to require complete removal of all suspended matter from the water is impractical, so it was suggested that an allowance of 8 lb of −325 mesh suspended solids per ton of clean coal produced be permitted in the washery effluent discharged to the stream system. A number of competent engineers experienced in the design and operation of coal preparation plants have studied and commented on the measure. That it could present difficulties is illustrated in the criticism by Parmley,[25] who writes that the following practical difficulties should be given consideration:

Case 1.

A mine with a R.O.M. feed of 400 T.P.H. with 35% refuse containing considerable fire clay and material that will disintegrate in water. Compared with a mine with 400 T.P.H. 10% reject and a solid shale reject. The one with 35% reject will have 260 tons of clean coal and is allowed only 2080 lbs. per hour waste. In this case the operator would have a very difficult clarification problem, yet is penalized and allowed less waste material than the operator with 10% reject. In the case of 400 T.P.H. with 10% reject there will be produced 360 tons of clean coal with an allowance of 2880 lbs. per hour. In all likelihood with this case the clarification system would be very efficient and there would be less than 8 lbs. per ton wasted.

Case 2.

Take two operators with 400 T.P.H. R.O.M.—one with 40% minus ¼" material and the other with 20% minus ¼". The one with 40% minus ¼" would have a very difficult settling problem yet would be allowed only the same wastage as the one with 20% minus ¼".

Case 3.

The most glaring example is a plant with a capacity of approximately 2400 T.P.H. feed and 30% reject, giving a clean coal of 1680 T.P.H. There would be a wastage of 11840# (5.92 tons) per hour or 83 tons per 14 hour day. This is a lot of material to run to the stream. The question is how can this tonnage be wasted to the river. If wasted with water at the rate of 200 G.P.M. with 11840# per hour or 197 lbs. per minute of solids would give a water containing 10.6% solids. This wastage would be very black and no state inspector would allow such a wastage to go to the river. Yet, according to the tonnage standard, it would be legal.

Now, consider wasting in say 4000 gal. per min. (which would be very impractical), the % solids in the wastage would be ½ of 1%. With only ½ of 1% solids, the waste water would be gray and would probably be allowed to flow into the stream.

Case 4.

Take an operator with 200 T.P.H. and 15% reject or 170 T.P.H. of clean coal. The allowable wastage would be 1360 lbs. per hour or 23 lbs. per minute.

The amount of water wasted would probably depend on the operator's water source or scarcity. Wasted with 23 G.P.M. of water would give 10% solids. Due to blackness of the wasted water, it would not be allowed. If the operator had to waste the same amount of solids upon a visually approved wastage of ½ of 1%, it would be necessary to waste at the rate of 500 G.P.M. This would likely be

prohibitive and uneconomical from the operator's standpoint.

It is realized that in all of the above cases the state would say that although the standards would be met, it would be up to the operator to install clarification equipment or waste the higher gallonage. It would be up to him to choose his method.

It is felt that a standard should be based on the % solids in the wasted water and limited to a maximum top size in the solids.

Just what criteria will be used it is hard to say, but that one will be adopted is certain.

The problem of a sliming clay, mentioned in Case 1, has an important bearing on the method of clarification. During recent years, the trend in the bituminous coal fields has been toward full seam mining, employing completely mechanized methods. A decade or more ago the quantity of refuse discharged from the coal preparation plant was approximately 15 to 20 pct of the raw feed. The modern plant must dispose of 25 to 35 pct of the raw feed as refuse, which in many cases contains clay material that breaks down in the wash water into fine sliming materials approaching a colloidal condition. When such situations are encountered, the washery water becomes heavily overloaded with suspended solids that are very difficult to settle in any reasonable retention time. However, that rate of settling has been increased through the use of flocculants that cause the clay to form flocs. The treatment has been varied to suit local conditions, but it is adequately covered in the literature by Samuel[26] and many others.

The acid water drainage and the discharge of washery water carrying suspended solids are the major problems encountered in the coal industry. There are other minor difficulties such as the oil slick carried off by rainfall where dust-proofing oil employed at the loading booms of the preparation plant has spilled on the ground. These are local occurrences, however, and can easily be corrected.

It is quite apparent that the coal industry is becoming aware of the demand for stream pollution control and is contributing to the research programs that are being carried on at various institutions in an effort to find some solution to acid water. To date no satisfactory treatment has been found.

Legal Controls on Stream Pollution

Industry and municipalities are becoming better informed on the obligations placed upon them through the recent legislation governing water supply and stream pollution. They are in more frequent contact with the officials of the commissions and boards that have been appointed to administer the various State, Interstate, and Federal laws and compacts. At the Federal level, Public Law 845, the 80th Congress, was adopted "to provide for water pollution control activities in the Public Health Service of the Federal Security Agency and for other purposes." Since this law was passed, the Public Health Service Agency has become increasingly active in all phases of stream pollution, and its activities will continue.

The Ohio River Valley Water Sanitation Compact, ratified by the legislatures of the eight states embraced by the Ohio River basin, outlines in the Preamble the reasons for the compact, namely:

> The rapid increase in the population of the various metropolitan areas situated within the Ohio drainage basin, and the growth in industrial activity within that area, have resulted in recent years in an increasingly serious pollution of the waters and streams within the said drainage basin, constituting a grave menace to the health, welfare and recreational facilities of the people living in such basin, and occasioning great economic loss.
>
> The control of future pollution and the abatement of existing pollution in the waters of said basin are of prime importance to the people thereof, and can best be accomplished through the cooperation of the States situated therein, by and through a joint or common agency.

The Interstate agreement between the various states in the Potomac River basin is similar in intent to the foregoing quotation.

The Commonwealth of Pennsylvania adopted a Clean Streams Act of 1937. It was amended in 1945 to include culm and silt, or suspended solids, from coal mines and coal cleaning plants. In this law, *pollution* is construed to mean the discharge to or the effects on the stream system of noxious and deleterious substances, "rendering unclean the waters of the Commonwealth to the extent of being harmful or inimical to the public health, or to animal or aquatic life, or to the use of such waters for domestic water supply, or industrial purposes, or for recreation."

Industrial wastes are construed to mean "any liquid, gaseous or solid substance, not sewage, resulting from any manufacturing or industry, or from any establishment, which causes pollution as defined, and silt, coal mine solids, rock, debris, dirt and clay from coal mines, coal collieries, breakers, or other coal processing operations."

At least 45 states have adopted some type of legislation for the conservation of water resources and the control of stream pollution. It is interesting to note that many of the states have patterned their laws on many of the clauses contained in the Pennsylvania Act No. 177, 1945, the Brunner Bill.

The enforcement of these stream pollution control laws is generally assigned to regulatory bodies or commissions appointed by the governors of the individual states. Generally the regulatory bodies are vested with almost unlimited powers. On the other hand, it is unfortunate that there is no system of checks and limitations on their acts and requirements and that they cannot be held responsible for any economic effects which may be brought about by the fullfillment of their requirements.

Wachter[27] has drawn attention to this potentially dangerous situation:

> It is characteristic of pollution abatement laws that the Commissions are not required to relate abatement requirements to actual or potential human uses of the streams. They customarily fix standards which relate theoretical stream conditions to theoretical possible uses, but are not required to relate specific requirements to actual conditions and uses. Consequently, many of them, under the laws by which they operate, have the power to require unrealistic and unnecessarily expensive degrees of treatment whether human purposes are served or not.

In such circumstances the success of the whole control program depends on the sagacity of the members of the commission.

Industry must keep fully informed of the various actions and decisions handed down by the Courts in relation to stream pollution. A case of far-reaching importance in its implications was decided by the Pennsylvania State Supreme Court. A coal mining company, using stripping methods, commenced operations on a clean stream water shed. The State Sanitary Water Board sought an injunction against

the company in Dauphin County Court, since mining operations were started without a permit. The Court ruled that mining could continue, if the streams were not polluted, and ignored the contention that a permit was necessary. The Supreme Court reversed the decision on the permit question, and ruled that the Commonwealth was justified in seeking assurance that any new mining operations will not destroy the purity of a stream before issuing a permit. Thus it is practically incumbent on the Sanitary Water Board to assure itself that no new coal stripping operation is a potential source of pollution on a clean stream.

Such a responsibility, "if the Law allows it and the Court awards it," can create inequities that may cause great hurt. Two examples may be cited.

An owner of land acreage invested in rural acreage and purchased with it the mineral rights of any underlying coal seam. Subsequently, on his applying for a permit to mine the coal, the permit was denied because of a potential pollution hazard. Therefore the owner could not realize, or retrieve, his investment.

The second case is a marginal mine that is a source of employment for an isolated community of 900 persons. The property is operated at a loss, but is kept going because of the community. The mine-washing plant is polluting a nearby stream with suspended solids. Any capital expenditure to remove the solids from the water discharged cannot be justified. Economics would require that the whole operation be abandoned, and the livelihood of the community would be at an end.

Such questions as these would tax the wisdom of the members of any commission. The economic effects of all abatement programs should be carefully weighed, and the relative benefits of each scheme should be compared to assure the community the most balanced program for all its needs. Such decisions call for rare judgment. Determining the relative importance of the esthetic and recreational values as compared to local economic considerations is especially difficult but frequently necessary. Employing rational means for attacking the problem may leave a lot to be desired because the influence of the emotional and psychological bias of society plays a great part in the decision.

Little has been said regarding the equally formidable problem of providing adequate sewage treatment plants for centers of population. Many of the great cities of the USA have no treatment plants at all. The human wastes from numerous communities are discharged directly into the stream system or to tidewater. To install modern plants for centers like Pittsburgh, Louisville, or Cincinnati is a stupendous task and requires sound financial planning. Engineering techniques are, however, well known.

Erosion caused by run-off of rainfall has not been touched upon, although the stream systems of the country carry stupendous quantities of silt to the sea. Radioactive substances in the sewer systems that receive the wastes from hospitals in city centers are also a factor. Time does not permit consideration of these and many other conditions.

Conclusion

The method of attacking the whole problem of stream pollution is made extremely difficult because of the meager knowledge of the specific effects of the numerous wastes of various quantities and concentrations that enter the river basin. Little is known of their action on aquatic life, nor the interaction between themselves. A great field of investigation lies ahead, and it is to be hoped that greater knowledge will be available in the coming years for guidance of the planners and the administrators of these comprehensive programs for the conservation of the country's water resources.

References

[1] Ernest R. Abrams: Is Texas Running Dry? *Public Utilities Fortnightly*, January 19, 1951.

[2] Report of the President's Water Resources Policy Commission: *A Water Policy for the American People.*

[3] Sheppard T. Powell and A. Chesley Wilson: Conservation of Water Resources. *Proceedings* 5th Annual Waste Conference, Purdue University.

[4] William E. Warne: Action on Groundwater Problems. *Engineering News Record*, Feb. 17, 1949.

[5] Engineers Joint Council: *Principles of a Sound National Water Policy*, July 1951.

[6] Richard M. Foose: Ground Water Conservation and Development. *Bull.* Department of Internal Affairs, Commonwealth of Pennsylvania, January 1951.

[7] D. W. Van Tuyl: Air Conditioning and Ground Water in Pittsburgh. *Bull.* Department of Internal Affairs, Commonwealth of Pennsylvania, July 1951.

[8] Interstate Commission on the Delaware River Basin: *The Delaware River Basin Water Project.*

[9] Private communication from Leathen and Braley, Mellon Institute of Technology, Aug. 27, 1952.

[10] E. F. Eldridge: *Industrial Waste Treatment Practice.* McGraw-Hill Book Co., New York, 1942.

[11] E. B. Phelps: *Stream Sanitation.* John Wiley and Sons, Inc., New York, 1944.

[12] U. S. Public Health Service: *Acid Mine Drainage Studies*, Supplement C, Ohio River Pollution Survey, 1942.

[13] S. A. Braley: *Survey of Mine Drainage.* Mellon Institute of Industrial Research.

[14] L. V. Carpenter and L. K. Herndon: *Acid Mine Drainage from Bituminous Coal Mines.* Research Bull. No. 10, Engineering Experiment Station, West Virginia University.

[15] S. A. Braley: *Special Summary Report on Mine Acid Control.* Mellon Institute of Industrial Research.

[16] Parr and Powell: *A Study of the Forms in Which Sulphur Occurs in Coal.* Illinois Engineering Experiment Station *Bull.* No. 11.

[17] M. E. Hinkle and W. A. Koehler: The Action of Certain Micro-organisms in Acid Mine Drainage. *Trans.* AIME (1948) **177**.

[18] K. L. Temple and A. R. Colmer: The Antotrophic Oxidation of Iron by a New Bacterium: Thiobacillus Ferrooxidans. *Journal of Bacteriology*, 1952.

[19] L. D. Tracy: Mine-Water Neutralizing Plant at Calumet Mine. *Trans.* AIME (1921) **66**, pp. 609-623.

[20] Sanitary Water Board, Department of Health, Commonwealth of Pennsylvania: *A Pilot Plant Study of the Neutralization of Acid Drainage from Bituminous Coal Mines.*

[21] U. S. Bur. Mines, Dept. of Interior: *Minerals Year Book*, 1941.

[22] S. H. Ash, E. W. Felegy, D. O. Kennedy, and P. S. Miller: Acid-Mine-Drainage Problems—Anthracite Region of Pennsylvania. U. S. Bur. Mines *Bull.* 508, 1951.

[23] Edward Griffith: Mine Drainage in the Anthracite Regions of Pennsylvania. *Trans.* AIME (1946) **168**, pp. 127-144

[24] E. W. Felegy, L. H. Johnson, and J. Westfield: Acid Mine Water in the Anthracite Region of Pennsylvania. U. S. Bur. Mines Tech. Paper 710, 1948.

[25] S. M. Parmley: Private communication.

[26] J. O. Samuel: The Flocculation of Coal—Clay Dispersions. *Journal of the Institute of Fuel*, September and November, 1951.

[27] F. C. Wachter: Industry's Interest in Water Pollution Abatement. Trans. *Bull.*, Industrial Hygiene Foundation, 1951.

Upgrading Domestic Manganese Ores By Leaching with Caustic Soda

by R. V. Lundquist

Leaching manganese-bearing materials with NaOH to remove caustic-soluble silica has been demonstrated as a method for upgrading manganese. Those materials containing opaline varieties of silica respond most readily. Spent leach liquors are regenerated by treatment with lime to precipitate calcium silicate and to reactivate the NaOH for leaching.

ALL of our larger domestic deposits of manganese are very low grade, but estimated tonnages in these deposits are large enough to constitute a potential strategic reserve of manganese for emergency periods, provided these ores can be upgraded sufficiently to meet industrial specifications. Many types of processes have been suggested for upgrading these ores, several have been studied in pilot plants, and a few have attained limited commercial production for special purposes.

The hydrometallurgical process to be described below proposes a leaching operation for removing caustic-soluble silica and other gangue minerals and consequently upgrading a manganese ore or flotation concentrate to a commercially acceptable product. It is known that some forms of silica and some silicate minerals are soluble in NaOH solutions under suitable conditions. This new process proposes to use NaOH for removing the soluble materials from manganese ores or concentrates and, as a result, upgrade the manganese content. Since spent leach liquors are not efficient leaching agents the liquor must be treated with lime to precipitate calcium silicate and reactivate the NaOH.

Experimental Procedure

Manganese-ore samples ground to −35 mesh were leached in iron containers into which the ore sample and appropriate NaOH solutions were placed. Flotation concentrates were already ground to −200 mesh. The slurries were then placed on a hot plate or into a pressure digester and stirred continuously during the period of digestion. Where the digestion was performed at atmospheric pressures, water lost by evaporation was replaced at regular intervals to maintain approximately a constant volume of slurry. In the pressure digester, volume changes were not controlled. After digestion, the slurry was allowed to cool enough for easy handling, but it was filtered hot, 50° to 70°C, on a Buechner filter. Filtration under these conditions was satisfactory. The resulting filter cake was washed and dried.

In most instances, a single leach would not produce maximum extraction of silica from the ore sample; consequently, the dried tailing was treated again in the same manner with a fresh solution of NaOH to obtain an additional extraction of silica. This procedure was repeated a number of times to get the maximum extraction of silica. Usually three or at most four stages of leaching were adequate for this purpose.

Table I. Analysis of Artillery Peak Flotation Concentrate

Item	Pct
Mn	31.65
SiO_2	20.97
Al_2O_3	3.12
FeO	3.11
CaO	3.24
BaO	8.02
K_2O	1.73
Pb	0.93
SO_4	0.66

This leaching procedure was used for obtaining the data reported in this paper on the effects of NaOH concentration, pulp dilution, temperature, and time of digestion on the efficiency of extraction of silica from the ore sample.

The experimental procedure does not match industrial methods. Consequently tests for countercurrent leaching were set up. Data from these tests are not yet complete, but in a qualitative way they indicate that thickeners between stages of leaching will be satisfactory and that the quantity of silica in a leach liquor moving forward to a new solid has only a minor effect on the quantity of silica extracted from the new solid. A pilot plant is now being designed for operation in the near future to test and evaluate the merits of this process.

R. V. LUNDQUIST, Member AIME, is Metallurgist, United States Bureau of Mines, Boulder City, Nev.

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Table II. Effects of Time and Temperature on Leaching Artillery Peak Flotation Concentrates, First-Stage Leach

Test	Time, Hr	Temp, °C	Initial Pulp Dilution	NaOH, G Per Liter	Extraction, Pct		Analysis of Tailings, Pct		
					SiO_2	Al_2O_3	Mn	SiO_2	Al_2O_3
105A	1	160	2 to 1	401.9	61.2	6.3	36.27	9.40	3.38
105B	1 1/3	160	2 to 1	401.9	64.6	9.0	36.07	8.64	3.30
105C	2	160	2 to 1	401.9	65.4	7.2	36.37	8.40	3.36
105D	2½	160	2 to 1	401.9	63.8	9.0	36.67	8.84	3.30
87	4¼	160	2 to 1	383.2	67.0	12.4	36.30	8.12	3.20
83	1 1/6	160	2 to 1	412.8	64.1	5.5	36.20	8.68	3.40
74A	½	90	2 to 1	397.2	39.8	5.3	34.63	14.14	3.31
74B	1	90	2 to 1	397.2	42.3	0	35.00	13.44	3.61
74C	1½	90	2 to 1	397.2	45.1	0	35.10	12.86	3.55
74D	2	90	2 to 1	397.2	48.3	6.1	35.50	12.12	3.28
70A	4	91	2 to 1	398.4	47.7		36.00	12.30	

Artillery Peak Experiment. Kingman, Mojave Co., Ariz.: A flotation concentrate from this ore was used to determine the optimum conditions for leaching with NaOH solutions. This flotation concentrate contained quartz, chalcedony and opal as its major gangue constituents, feldspar and calcite as intermediate constituents, and amphibole, limonite, barite, clay, and gypsum as minor constituents. Analysis is shown in Table I. This concentrate was ignited at 1200°C and the manganese content thus increased to 36.57 pct.

Table II shows the effect of time and temperature on leaching. At 90°C, maximum extraction for a single leach was obtained after 2 hr of leaching when 48.3 pct of the silica was extracted. Under similar conditions, but at a temperature of 160°C, which corresponds to a steam pressure of 75 psi, 65.4 pct of the silica was extracted. Longer periods of leaching did not materially increase the extraction, but increased temperature markedly improved the extraction of silica.

In this paper, pulp dilution or ratio of solution to ore is expressed as the volume of liquor in milliliters per unit weight of concentrates in grams. This avoids the necessity of considering the specific gravity of the solutions each time. When 30 pct NaOH, 398.4 g per liter, solution is used the corresponding approximate weight ratios and percent solids are as follows:

Pulp Dilution	Wt Liquid / Wt Solids	Solids in Pulp, Pct
2 to 1	2.65	27
3 to 1	3.98	20
6 to 1	7.95	11

Table III shows the effect of pulp dilution and the number of stages of leaching on the extraction of silica. Here it is noted that the more dilute pulps showed the best extractions of silica, also, that each additional stage of leaching increased the extraction, and the increased extraction per stage decreased as the number of stages increased until maximum extraction had been obtained. Further, a single stage of leaching at 160°C produced approximately the same extraction of silica as four

Table III. Cumulative Effects of Stage Leaching

Test	85	70	69	68	77	75	76
Time, hr	2	4	4	4	3	3	3
Temperature, °C	160	91	93	95	90	90	90
NaOH, g per liter	403.0	398.4	398.4	398.4	248.7	248.7	248.7
Pulp dilution	2 to 1	2 to 1	3 to 1	6 to 1	2 to 1	3 to 1	6 to 1
First stage							
Extraction, pct:							
SiO_2	64.5	47.7	50.3	54.7	48.0	50.1	55.3
Al_2O_3	7.7		0	1.8	0	3.6	26.4
Weight loss, pct	14.4	10.9	12.3	16.5	11.8	12.8	12.9
Residue, pct:							
Mn	36.15	36.0	35.8	36.4	35.54	35.94	36.38
SiO_2	8.70	12.3	11.88	11.36	12.34	12.00	10.76
Al_2O_3	3.36		4.34	3.66	3.55	3.45	2.64
Second stage							
Extraction, pct:							
SiO_2	68.3	55.8	57.7	63.0	54.2	57.1	59.2
Al_2O_3	15.7	2.1	2.7	13.8	4.7	18.1	31.2
Weight loss, pct	17.0	14.5	15.5	20.5	13.8	15.7	16.3
Residue, pct:							
Mn	36.30	36.6	37.0	37.6	36.33	36.73	37.57
SiO_2	8.02	10.86	10.48	9.76	11.14	10.66	10.22
Al_2O_3	3.16	3.58	3.58	3.38	3.45	3.03	2.56
Third stage							
Extraction, pct:							
SiO_2	75.0	63.3	63.1	66.8	56.9	60.5	61.4
Al_2O_3	19.1	15.2	6.4	33.5	16.4	30.1	29.9
Weight loss, pct	21.2	16.4	17.7	22.0	15.3	17.7	16.4
Residue, pct:							
Mn	38.1	38.5	37.6	38.7	36.98	37.62	38.21
SiO_2	6.64	9.22	9.40	8.92	10.68	10.06	9.68
Al_2O_3	3.20	3.18	3.54	2.66	3.08	2.65	2.62
Fourth stage							
Extraction, pct:							
SiO_2		63.2	67.1	70.5	60.1	64.1	65.4
Al_2O_3		14.6	31.7	48.4	22.4	42.6	33.2
Weight loss, pct		18.0	19.9	23.6	17.0	18.8	17.9
Residue, pct:							
Mn		37.52	38.51	39.40	37.27	37.87	38.81
SiO_2		9.44	8.60	8.10	10.08	9.28	8.84
Al_2O_3		3.27	2.64	2.10	2.92	2.21	2.54
Ignited at 1200°C:							
Ignition loss, pct		13.83	14.20	13.95	13.33	14.20	14.87
Mn, pct		43.41	45.08	45.86	43.13	44.12	45.33

stages of leaching at 90°C. The concentration of NaOH, within the range tested, had only minor effects on the extraction of SiO_2.

It is difficult to explain the data for the extraction of alumina; although significant increases in extraction were obtained, they did not follow a regular pattern. It appears that increased extraction occurred after the major portion of the soluble silica had been removed in earlier stages of leaching. This may be related in some manner to the low silica content of the liquors in later stages.

Optimum conditions for leaching appear to be somewhat as follows. Caustic concentration should be in the range of 243.8 to 398.4 g per liter NaOH. Lower concentrations were found to be less effective. A pulp dilution of 6 to 1 was most effective, but because large volumes of liquor must be handled, pulp dilutions in the range of 2 to 1 to 3 to 1 may be more desirable. A leaching time in the range of 2 to 3 hr was effective, and the choice of temperature for leaching lies between leaching at atmospheric pressure and pressure digestion.

Pulps for study of settling rates were prepared by leaching in the above manner. Initial settling rates under several sets of conditions were fairly consistent and varied in the range of 0.41 to 0.59 ft per hr. Corresponding final settling rates varied in the range of 0.08 to 0.25 ft per hr, and the thickened pulp contained 45.8 to 55.2 pct solids. Area requirements varied in the range of 10 to 15 sq ft per ton-day of dry solids. Concentration of NaOH, pulp density, and temperature of pulp when settling had little effect beyond the variations noted above.

Filtration studies were made with a laboratory Oliver United Filter leaf with an area of 0.1 sq ft, using Vinyon 101N for the filter cloth. Pulps were prepared by leaching in the manner described above. Data from these tests were irregular in trend except for showing improved filtration at higher temperatures for the slurry and with increased pulp density. For a pulp dilution of 1 to 1 the area required to filter one ton of dry solids in 24 hr was 10.6 sq ft for filtering at a slurry temperature of 25°C. When filtering was done at a temperature of 65°C the area required was reduced to 9.2 sq ft. When slurry having a pulp dilution of 6 to 1 was filtered, at the same temperatures as noted, the corresponding area requirements were 59.2 and 31.8 sq ft. These values show the irregular nature of filtration data as obtained from this filter leaf. The concentration of NaOH in the slurry did not show any pronounced effects, but the blinding of the filter cloth with slimes very markedly slowed the filtration rate.

Filtration on a Buechner filter, while not evaluated quantitatively, showed no unusual difficulty. In some instances where leach liquors had been allowed to cool to room temperatures filtration was slow. This was also the case for the denser pulps where the liquors contained a high concentration of silica. On cooling, these tended to become viscous and to crystallize out sodium silicate, which hinders filtration. The crystals of sodium silicate redissolve readily on heating the liquor to about 60°C.

Washing a filter cake ¼-in. thick with hot water equivalent to 1.5 lb of water per lb of dry solids produced a cake containing 0.21 pct NaOH or 4.2 lb of water-soluble NaOH per ton of dry solids. But along with this, an additional quantity of NaOH appears to be tied to the solids by stronger bonds, for the residues contained a total of 1.64 pct Na_2O, whereas the initial solids before leaching contained only 0.17 pct. The difference between these values represents NaOH permanently removed from the leach liquor by the cake. This amounts to 38 lb of NaOH per ton of dry solids. Prorating this value to the original concentrates reveals a loss in leaching of 32 lb NaOH per ton of concentrates treated. Of this loss, less than 4 lb can be recovered by additional washing.

Table IV. Leaching Charleston Hill National Mines Ore

Test	Pulp Dilution	NaOH, G Per Liter	Temperature of Leach, °C	SiO_2 Extracted, Pct	Weight Loss, Pct	Tailings Analysis, Pct: Mn	Tailings Analysis, Pct: SiO_2
103A	3 to 1	387.4	91	8.0	2.3	31.46	44.8
103B	3 to 1	401.9	91	8.5	3.6	31.46	45.2
106A	2 to 1	397.0	120	27.2	11.4	34.47	39.12
106B	2 to 1	397.0	125	44.6	20.5	38.09	33.04
110A	2 to 1	380.8	140	61.8	29.9	42.69	25.96
110B	2 to 1	372.0	145	80.3	40.0	49.50	15.60
109A	3 to 1	396.0	160	85.0	41.1	51.90	12.10
109B	3 to 1	396.0	160	89.8	43.6	53.30	8.60
104A	2 to 1	245.1	160	72.1	34.7	46.49	20.36
104B	2 to 1	245.1	160	86.0	39.0	51.90	10.90

The A and B designations are first- and second-stage leaches, respectively.

Charleston Hill National Mines, Winnemucca, Nev., Experiment: Two samples of this ore were tested, and both consisted almost entirely of cryptocrystalline or metacolloidal silica carrying the manganese minerals. No quartz was observed in either sample. Table IV presents the results for the leaching of one of these samples. These data illustrate very vividly the effects of temperature on the leaching of silica from this ore, with consequent increase of manganese values. The head sample for these tests contained 30.83 pct manganese and 47.60 pct SiO_2. At 90°C only 8.5 pct of the SiO_2 present was removed by leaching, while at 160°C, 89.8 pct was extracted; respective manganese values were 31.46 and 53.3 pct. Tests 103 and 106 were run at atmospheric pressures, and the temperature for the latter test was near the boiling point for the slurry. Tests for the higher temperatures were run in a pressure digester. Values for the silica extraction and for weight loss are cumulative effects for the two stages of leaching. The other sample contained 18.5 pct Mn, 67.1 pct SiO_2, and 0.6 pct Al_2O_3. Leach-

Table V. Leaching of Other Cres

Source of Ore Sample	Head Analysis, Pct: Mn	Head: SiO_2	Head: Al_2O_3	Head: Fe	Leach Tail Analysis, Pct: Mn	Tail: SiO_2	Tail: Al_2O_3	Tail: Fe	SiO_2 Extracted, Pct
Aroostook, Maine	13.5	23.7	8.5	21.0	14.8	13.5	9.1	25.9	52.0
Rhodonite	29.3	48.7			35.6	38.0			
Three Kids manganese ore, Henderson, Nev.									
Stockpile No. 2	24.1	31.1	6.3		28.2	18.3	6.7		50.5
Rougher concentrate	34.2	16.2			36.2	8.9			52.0
Cleaner conncentrate	38.4	8.8			39.9	5.7			37.4

ing produced a concentrate carrying 54.1 pct Mn and 11.9 pct SiO_2 where 90.8 pct of the SiO_2 was removed.

Other Ores Tested: Several other ores were tested in a similar manner with results as recorded in Table V. These data demonstrate the degree to which other types of ores will respond to leaching in NaOH solutions. In correlating the degree of leaching with the types of ores or concentrates leached one observes that those samples containing cryptocrystalline silica respond most readily, while those that carry quartz and silicate minerals are more refractory to this method of treatment for upgrading manganese. The leaching of rhodonite appears to have removed mostly the silica in excess of that required for the mineral. The Three Kids Stockpile No. 2 sample contained quartz, chalcedony, and opal as major gangue constituents; calcite, gypsum, clay, barite, and feldspars as intermediate constituents; and muscovite, biotite, and epidote as minor gangue constituents.

Additional points of interest were determined during leaching of Three Kids ore. Here a wider range of NaOH concentrations was used for leaching, and for conditions similar to those shown in Table II the following extractions of silica were obtained:

NaOH, G Per Liter	SiO_2 Extracted, Pct
110.9	27.9
174.7	34.5
243.8	40.9
318.6	43.1

These data demonstrate the optimum concentration of NaOH required to obtain satisfactory extraction of silica. Further, the Stockpile No. 2 sample carried 1.8 pct lead. This lead could not be extracted to any appreciable degree by the leaching procedure employed.

Regenerating Caustic Leach Liquors

The leaching of manganese ores or flotation concentrates with caustic soda produces a liquor containing essentially a sodium silicate. As the silica concentration in the leach liquors increases, there is a decrease in the efficiency of leaching, and it becomes necessary to regenerate the NaOH in spent leach liquors to restore their leaching efficiency and recover NaOH for further leaching. Regeneration, then, becomes an important secondary operation for the process. Spent leach liquors were regenerated by adding lime to precipitate calcium silicate and free the NaOH, according to the general equation:

$$Ca(OH)_2 + Na_2O \cdot SiO_2 = CaO \cdot SiO_2 + 2NaOH$$

In using this reaction for regeneration, one must know the conditions under which it will function most efficiently. The following discussion and data outline those conditions.

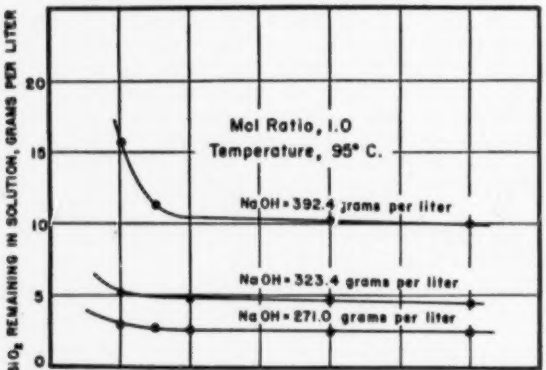

Fig. 1—Effect of reaction time on the regeneration of NaOH, when a lime-to-silica mol ratio of 1.0 is used.

Experimental Procedure: Spent caustic leach liquors from leaching operations were made up into slurries by adding appropriate quantities of dry lime, added at a definite mol ratio of CaO to SiO_2, based on the SiO_2 present in the liquor sample. The slurry was then placed in a water bath to maintain a constant temperature during the reaction period and stirred vigorously at regular intervals. After an appropriate reaction time, the slurry was filtered on a Buechner filter at temperatures corresponding to those used for the reaction but not greater than 60° to 75°C. Filtrates were analyzed for total NaOH by titrating with a standard acid, and no distinction could be made between free caustic and that combined with silica. The silica remaining in the liquor after regeneration was used as a measure for its efficiency. Relating this value to other variables outlined the optimum conditions required for regeneration.

Experimental Results and Discussion: The effective regeneration of calcium silicate was obtained by adding dry fresh-burned lime to the spent leach liquor in a mol ratio of lime to silica of 1.0 and reacting this mixture for a period of 2 hr at a temperature above 60°C. Lower temperatures and shorter periods of time were less effective in producing a calcium silicate that was readily handled. Reaction periods in excess of 2 hr and mol ratios in excess of 1.0 did not materially improve the process of regeneration. Fig. 1 illustrates the effects of reaction time vs the grams per liter of silica remaining after regeneration. The shift in location of these curves is due to differences in NaOH concentration in solutions from which precipitation was made. Fig. 2 explains this shift. Nearly identical curves in shape and location were obtained for mol ratios of lime to silica vs grams per liter of silica remaining. The initial silica concentration in the spent leach liquors had no effect on the progress of regeneration, except that liquors containing 75 g of silica per liter or more could not be regenerated because such slurries became thick muds that would not flow readily. Those solutions containing 50 g of silica per liter could be handled easily.

The effects of NaOH concentration on regeneration were very pronounced and in these tests the concentration was varied from 200 to more than 400 g of NaOH per liter. In Fig. 2 the grams of silica per liter remaining after regeneration are plotted in comparison with the concentration of NaOH in the solution from which precipitation was made. In every case where the mol ratio of lime to silica was 1.0 or more, the final value for the silica remaining in the leach liquor fell near Curve A. It suggests that equilibrium conditions of some kind were established between the reactants and the products. It follows, therefore, that for liquors of a given NaOH concentration containing less silica than a value determined by Curve A, little silica will be precipitated by the lime and, further, that for higher silica values only that portion above Curve A will be precipitated.

A mol ratio of lime to silica of 0.57 was used for precipitation for obtaining Curve B in Fig. 2. This

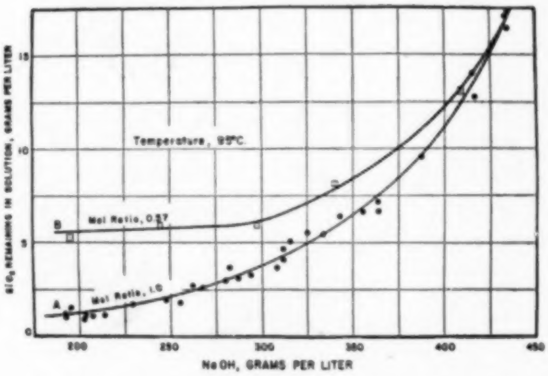

Fig. 2—Effect of NaOH concentration on regeneration, when lime-to-silica mol ratios of 0.57 and 1.0 are used.

curve shows that for the lower concentrations of NaOH an insufficient quantity of lime had been added to meet the demands required by Curve A and, therefore, that portion of Curve B is flat. However, as the concentration of NaOH increases, this quantity of lime added approaches and finally equals or exceeds the demand for Curve A. Consequently the two curves approach each other and finally merge. The silica left in solution representing the difference between Curve A and Curve B can be precipitated by the addition of an appropriate quantity of lime.

The slimy nature of calcium silicate precipitates precludes the use of thickeners for separating the solids from the liquor except for very dilute slurries. The heavier slurries must be filtered to make the separation, and filtration on a Buechner filter proceeded at a satisfactory rate for solutions containing 350 g of NaOH per liter or less. For the more concentrated solutions the filter rate decreased rapidly as the NaOH concentration increased. The unwashed filter cakes contained about 65 pct moisture.

Washing these cakes with about 3.5 volume displacements of hot water reduced the NaOH retained to about 5 pct of the weight of the dry solids. This is an average value for retained NaOH that varied somewhat with the concentrations of NaOH in the initial liquor, cake thickness, cracking of the cake, and the physical nature of the solids. Extreme values for retained NaOH varied from 1 to 10 pct and the wet washed cake retained about 80 pct moisture.

It was found that fresh-burned lime produced excellent results for regeneration when it was slaked in the spent leach liquor to be regenerated. Hydrated lime added in the same manner did not produce comparable results. The following analysis of a calcium silicate precipitate was typical of those obtained:

Item	Percent
CaO	38.0
SiC_2	38.5
Na_2O	3.6
Mol ratio CaO to SiO_2	1.055

From Table III it may be anticipated that about 280 lb of silica extracted from a ton of Artillery Peak flotation concentrates would have to be precipitated. This would require about 280 lb of lime and there would be about 727 lb of dry precipitate produced which would carry about 33 lb of NaOH. Combining this value with the loss occurring in leaching, there would be some 65 lb of NaOH lost in treating one ton of original flotation concentrates exclusive of all other losses.

Seeding Out Sodium Silicate: Spent caustic leach liquors will drop out crystals of sodium silicate on cooling and standing. This crystallization may be speeded by cooling the liquors to 20°C or less and adding a few small crystals of sodium silicate. To test the efficiency of this method for the removal of SiO_2, a liquor containing 286.7 g NaOH and 45.93 g SiO_2 per liter was cooled to 20°C, and a few small crystals of sodium silicate were added. In 1 hr, the entire volume was solid with loosely packed crystals. The mass was gently stirred and allowed to settle for 17 hr before the crystals were separated from the liquor. The new liquor had lost 19.0 pct of its original volume and now contained 268.4 g NaOH and 11.77 g SiO_2 per liter. Crystallization of sodium silicate had removed 24.1 pct of the NaOH and 89.2 pct of the SiO_2 from the original leach liquor. The mol ratio of Na_2O to SiO_2 in the crystals recovered was 1.43.

Build-up of Impurities in Leach Solutions: Certain minerals often found associated with manganese will react with NaOH to produce sodium compounds that will not readily regenerate NaOH. These compounds will in time build up and render the solution inert for leaching silica. Gypsum is a common associate in manganese ores, and it will convert NaOH into Na_2SO_4. Carbonates or carbon dioxide from a number of sources will produce Na_2CO_3. Potash, or K_2O, probably from the clay minerals, also accumulates in the leach liquors. Alumina showed no tendency to accumulate in the leach liquor. The rate at which these impurities accumulate and, therefore, the rate of decrease of leaching efficiency of NaOH was not determined. Undoubtedly, some system of periodic removal of these and other impurities must be incorporated in the flow sheet.

Summary

A study was made to determine the effectiveness of leaching manganese ores or flotation concentrates with NaOH solutions to remove soluble silica and silicate minerals. It was found that some types of ores or concentrates could be upgraded appreciably, producing concentrates carrying more than 40 pct manganese, and that the spent leach liquors could be regenerated for re-use in further leaching by treatment with fresh-burned lime to precipitate the silica as calcium silicate.

Acknowledgments

Research and development work on this process for upgrading manganese ores was conducted by the Bureau of Mines Manganese Research Section at the Electrometallurgical Experiment Station and Pilot Plants, Boulder City, Nev. The author is grateful for the many helpful suggestions and constructive criticism offered by Rex R. Lloyd, Chief of the Boulder City Station, and by James H. Jacobs, formerly engineer in charge of the Manganese Research Section. He wishes also to thank Charles T. Baroch, senior metallurgist, for his critical review of the manuscript. The author further acknowledges the work of Thomas E. Hill, Oliver O. Leone, and William H. Curry in conducting much of the experimentation, and the work of P. R. Perry and his assistants in performing the analyses required for this study. To all these people and to many others not mentioned who assisted in this work indirectly the author expresses his appreciation.

Technical Note

Double-Bond Reactivity of Oleic Acid During Flotation

by A. M. Gaudin and R. E. Cole

OLEIC acid, a standard flotation reagent, has generally been preferred to other fatty acids. Because oleic acid differs from saturated fatty acids by the presence of one carbon-to-carbon double bond and because the flotation operation is one in which extremely intimate exposure of the reagent to oxygen is obtained, it appeared possible that the value of oleic acid as a flotation collector was related to the oxidizability of its double bond.

To test this hypothesis, the floated mineral, fluorite, was leached with a solvent capable of extracting the adsorbed reagent and the extract was analyzed.[1] Results show that oleic acid is not oxidized during flotation, although some oxidation can be obtained if the flotation operation is repeated many times and if oxygen in place of air is employed as the gas during flotation. Incidentally, it was found that linoleic acid which has two nonconjugated double bonds is not affected appreciably more than oleic acid. Linolenic acid which has three nonconjugated double bonds is measurably altered even during one flotation step, using air.

The fatty acids used, from the Hormel Foundation, were of the highest purity. The quantity of fatty acids employed in each test was sufficient to float the mineral, but less than the theoretical amount required to form a monolayer at the mineral surface. The purpose of this limitation was to eliminate droplets of oil smeared on the adsorbate-covered mineral surface. The mineral was dried in vacuum at about 60°C. Effective leaching was obtained by use of a solution of 1 pct hydrochloric acid in absolute alcohol. The extract was separated from the solvent by distillation, with final recovery of the extract in carbon tetrachloride.

The identity of the extract was tested by a combination of analytical procedures including infra-red spectroscopy, saponification number, iodine number, and index of refraction. At the outset, great hopes for accurate quantification of oleic acid oxidation had been entertained in regard to the method of infra-red spectroscopy. Unfortunately, because the double bond in the oleic acid is so symmetrically located at the center of the molecule that it provides very weak absorption bands, accurate quantitative analyses were not obtained. Nevertheless, infra-red spectrograms suggested the absence of double-bond oxidation during flotation.

A. M. GAUDIN, Member AIME, is Professor of Mineral Engineering, Massachusetts Institute of Technology. R. E. COLE, Student Associate, AIME, was formerly a graduate student, Massachusetts Institute of Technology.

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Table I. Iodine Values of Extracted Adsorbates

Test No.	Fatty Acid Collector Used	Extract Iodine Values: Observed	Theoretical*	Calculated**
A	Oleic lot 5	80.62	81.75	81.21
B	Oleic lot 5	80.67	81.75	81.21
C	Oleic lot 4	81.28	81.75	82.34
D	Oleic lot 4	81.21	81.75	82.34
E	Linoleic	164.37	164.57	162.81
F	Linoleic	164.14	164.57	162.81
G	Linolenic	231.62	248.48	247.56
H	Linolenic	230.85	248.48	247.56

* The theoretical values listed are those of pure ethyl esters of the fatty acid collectors.

** Iodine values of the ethyl esters as calculated from the determined iodine values of the unused fatty acid collectors.

Iodine number, semi-micro method, provided a critical test of the extent to which fatty acids oxidized during flotation, see Table I. The index of refraction was used in a qualitative rather than quantitative fashion, and its findings corroborated those obtained by the iodine-number method.

It is concluded, in the case of fluorite and C-18 fatty acids having one or two nonconjugated double bonds, that there is practically no change of the fatty acid molecule or ion during the flotation operation. It would appear, therefore, that the extraordinary utility of these reagents is related to some property of the compounds other than the oxidizability of their double bonds.

Acknowledgment

The research reported herewith was sponsored by the Research Division, U. S. Atomic Energy Commission, and for this help the authors express their appreciation.

Reference

[1] R. E. Cole: "Double-Bond Reactivity of Oleic Acid During Flotation." Thesis submitted in partial fulfillment of the requirements for the degree of M.S. at the Massachusetts Institute of Technology.

More than 400 persons attended the First Mining Branch Dinner, almost definitely the high point of the Los Angeles Annual Meeting. Lewis W. Douglas, former U. S. Ambassador to the Court of St. James, addressed the gathering, presenting his views on a wide range of topics in an informal manner. The entire tone of the dinner set a standard for the years to come. Future affairs may prove to be the key to the success of annual meetings. During his talk, Mr. Douglas brought to bear his vast experience in international affairs in commenting on the proposed meeting of President Eisenhower and rulers of Soviet Russia.

175th General Meeting of AIME Acclaimed Success Technically and Socially

Andrew Fletcher, 1953 AIME President, left, chats with three Past Presidents of the Institute during an informal moment prior to the Annual Banquet. The Past Presidents are L. E. Young, 1949; W. M. Peirce, 1951; and M. L. Haider, 1952.

CLEAR sunny skies that prevailed all through the 175th General Meeting of AIME were not the least of the details that resulted from the many months and man-hours of planning by the Southern California Local Section. Some 2600 persons left the 1953 Annual Meeting technically enlightened, having had a choice of over 300 papers presented by 400 authors to listen to, learn from, and criticize. During the meeting, Mike Haider turned over the Presidency of AIME for 1953 to Andrew (Drew) Fletcher.

The Council of Section Delegates started the first of the official proceedings with their all day meeting on Saturday, February 14. The Board of Directors met on Sunday, as did the Student Relations Committee, and the MIED. Most technical sessions started Monday morning.

On Monday, the Welcoming Luncheon was the opening of business-social activities, all of which were done in the Hollywood manner. President Haider presided at the Luncheon, and introduced Henry Mudd, who officially welcomed the group on behalf of the Southern California

On the left, Raymond E. Byler, outgoing Chairman of the Mining Branch Council, M. L. Haider, center, 1952 past President of the AIME, and LeRoy Scharon, 1953 Mining Branch Chairman, chat informally following the Mining Branch Dinner. Right, Lewis W. Douglas drives home a point during his informal address to those attending the dinner. Mr. Douglas' appearance at the dinner was one of the outstanding events of the 1953 Annual Meeting.

Welcoming Luncheon

Local Section. In essence he remarked that it was wonderful to play host for the Annual Meeting despite the large volume of work involved. During introduction of the head table guests, Incoming President Fletcher was formally introduced and Desmond F. Kidd, President of the Canadian Institute of Mining & Metallurgy, extended greetings to the AIME on behalf of CIM.

Student prize awards of $100 each were made to William F. Hofmeister in the graduate div. and David F. Drinkhouse in the undergraduate div. Similar awards were made in absentia to Bruce W. Gilbert in the graduate div. and Benjamin C. Allen and Marvin A. Kunde in the undergraduate div.

Two membership contest awards are given annually by the President. The President's Banner is given to the Local Section gaining the greatest percentage of new members, and the Gavel, for the Local Section with the largest total of new members. The reason for the two awards is that the large and small section could be equally eligible. However, the Southwest Texas Section walked off with both awards, the result of intensive campaigns. Perhaps other Local Sections would do well to borrow a page from the methods book of this fast growing section. The Section also threatened to repeat this feat next year.

A. C. Rubel introduced Gov. Dan Thornton of Colorado, luncheon speaker. Gov. Thornton spoke on *Restraints or Responsibility*, with the major premise that if businessmen hold themselves responsible for carrying on the system of free enterprise, there need not be Government regulation. He stated that both he and the mining industry were firm believers in the free competitive enterprise system, and that the mining industry was built on those three keystones — freedom, competition, and enterprise. He advocated, "For government restrictions, let us substitute individual responsibility, for state control let us substitute self control." Gov. Thornton went on to suggest a four point program. First, incentive must be put back into private enterprise — and individuals must be able to make a reasonable profit from capital invested and effort expanded. Second, it must be realized that government has its proper place in the mining industry, but that place should be in technological research in production and utilization methods of our basic mineral resources. The third point is a fair tax system, which must not be so severe as to discourage risk capital, and not so lenient that the industry is not paying its just share of the cost of government. The last point of the Governor's program was the effect of good conservation practices upon the overall economic condition of the nation. Good conservation methods and practices are good business, he said.

Stag Dinner

Monday evening, preceding the stag-smoker, a cocktail party was provided for all meeting attendees by the Southern California Local Sec-

One of the matters discussed at the MGGD Executive Committee meeting was the possibility of establishing awards for outstanding young mining engineers. Attending the meeting were: Seated, from left to right; K. L. Cook, E. P. Pfleider, LeRoy Scharon, G. M. Schwartz, T. Koulomzine; standing, R. E. O'Brien, F. C. Krueger, C. M. Cooley, E. D. Gardner, and Tell Ertl.

A group at the informal dance look over a handful of prints made from pictures taken during the dance. They are from left to right: N. Van Wingen, Mrs. Tom Benton, Tom Benton, Mrs. Van Wingen, Ham Bell, and Mrs. Shannon Baker. Another group makes conversation around the table during time out from dancing. From the left they are Ralph B. Utt, Mrs. Ruth Whiting, Mr. Whiting, Mrs. Charles Biesel, Mrs. Erb Weusch, Mrs. Neal Plummer, Mrs. Ralph Utt, and Neal Plummer.

Mining Branch Dinner — *Informal Dance*

tion, with the cooperation of many companies in the mining, metals, and petroleum fields. Headline attractions for the smoker were Edgar Bergen and Charlie McCarthy, with the Sportsmen's Quartet and other acts.

At the annual Institute business meeting on Tuesday afternoon, yearly reports were presented on AIME activities and branches. At the close of the session, Andrew Fletcher, with the aid of Jerry Peirce and Erle Daveler, was inducted by Mike Haider in to the Presidency of AIME for 1953, in a simple ceremony. Publicly, the new President does not officiate until the close of the Annual Banquet.

Tuesday evening activities were keynoted by the first annual Mining Branch Dinner. With R. E. Byler presiding, and Lewis W. Douglas, former U. S. Ambassador to the Court of St. James, as guest speaker, this gathering was the real climax of Mining Branch functions at the 1953 Annual Meeting.

Mr. Douglas addressed a group of over 400, giving his feelings and convictions of the present day situation, national and international. He spoke informally and described things from the point of view of his personal experience as a business man and international statesman. Mr. Douglas expressed the feeling that a meeting between President Eisenhower and (at that time) Stalin might help to avert World War III. Quoting him: "We are not getting anywhere either through normal diplomatic channels or through the United Nations."

Following the Mining Branch Dinner, conferees and their ladies, including those from the other

Freddy Martin and his orchestra provided the music for the informal dance, with couples crowding the floor until the early hours. Breakfast was served at midnight, and the smell of bacon and eggs revived dance weary conferees. The music was smooth, the California skies clear, and the air cool—making the night perfect for dancing. Martin's signoff music was greeted with regret as a perfect evening came to a close.

Main group of the Annual Banquet dined in the combined Pacific and Sierra Rooms of the Hotel Statler. Two rooms were combined by raising a hydraulically operated wall. The Sierra Room may be seen at the left rear. Highlighting the evening's program was the presentation of the 1953 President, Andrew Fletcher. Mr. Fletcher outlined his plans for his term of office. Dancing followed the banquet, which featured presentation of awards for accomplishments during 1952.

Branch dinners, gathered in the ballroom of the Los Angeles Biltmore to listen and dance to the music of Freddy Martin and his Orchestra. The floor was filled continuously with dancers. Shortly after midnight, breakfast was served.

Wednesday evening, the last and most important of the social affairs took place. With the Annual Banquet, always impressive, the outgoing President presents the Institute Awards of the year, and then unshoulders the tremendous responsibilities of his office, transferring them to the new President. No retiring President has failed to breathe a sigh of relief at being released to carry on only his regular duties; but all have made their contribution to the Institute and its members, and feel that by serving the minerals industry, they have themselves gained.

Retiring President Haider presented the following Medals and Honors at the Banquet: The Charles F. Rand Medal to Eugene Holman, president, Standard Oil Co. (New Jersey); the Anthony F. Lucas Award to Morris Muskat, technical assistant to the vice-president of production, Gulf Oil Corp.; the Rossiter W. Raymond Memorial Award to A. N. Holden, research associate, Knolls Atomic Power Laboratory, General Electric Co.; the Robert H. Richards Award to Edward W. Engelmann, assistant general manager, Utah Copper Div., Kennecott Copper Corp.; the Robert W. Hunt Award to John Hugh Chesters, assistant director of research, The United Steel Companies, Ltd.,

Award winners, Legion of Honor members, and other dignitaries made up the head table during the Banquet. Among those present are W. M. Peirce, 1951 AIME President, Kenneth Van Horn, Andrew Fletcher, and M. L. Haider, 1952 President.

Turnout for the Annual Banquet was so huge that two sections were required to handle the diners. One group gathered in the Hotel Statler's Golden State Room. A total of 1366 persons attended the banquet for the largest turnout at an affair held outside of New York City.

England; Mathewson Gold Medals to Paul A. Beck, research professor, University of Notre Dame, Philip R. Sperry, research metallurgist, Kaiser Aluminum & Chemical Corp., and Hsun Hu, Institute for the Study of Metals, University of Chicago; and the J. E. Johnson, Jr. Award to Charles M. Squarcy, assistant superintendent, blast furnaces, Inland Steel Co. J. H. Chesters was absent.

With the keynote of brevity for the evening, Mike Haider expressed his appreciation for the cooperation given him during his term of office, and presented Andrew Fletcher, as speaker of the evening and AIME President. President Fletcher pledged himself to uphold the splendid examples set by his predecessors, and to continue and further the aims and objectives of the Institute. This was no idle boast, as the new President has for many years been in extremely close contact with the Institute as a Director and Treasurer. By their applause, the audience expressed their gratitude to Mike Haider, and their wholehearted support to Drew Fletcher. The formal ceremonies were closed with the traditional President's Reception. Dancing followed.

The Woman's Auxiliary duplicated the pace of the men's meetings with a complete and well rounded program of activities. Mrs. Harold J. Clark served as General Chairman of the Ladies' Entertainment Committee, with Mrs. M. L. Haider and Mrs. Andrew Fletcher as Honorary Chairmen. Included in the festivities were attendance at the Lux Radio Theater, Hollywood, Luncheon at the Farmers' Market, tour of Beverly Hills, followed by Tea and Reception at the Hilltop Estate of Mrs. Cooley Butler, and a Luncheon and Fashion Show. Business was attended to at the Annual Meeting on Tuesday morning,

The Woman's Auxiliary meeting was crowded to capacity, symbolizing the extensive program of activities arranged for the ladies at the Annual Meeting. Tours, theater parties, and style shows were only part of the week's whirl for the distaff side.

Mrs. D. F. Hewitt, Mrs. Harold J. Clark, Mrs. Cooley Butler, and Mrs. Felix Wormser, 1953 President of the Woman's Auxiliary, appear to be discussing the week's activities during a social event held at the Butler estate.

The Annual Meeting Committee was largely responsible for the success of the affair, putting forth a tremendous effort in organizing and running the gathering of members from all over the U. S. and various parts of the world. Among the committee men were, from left to right: Henry Mulryan, Field Trip Chairman; Ian Campbell, Banquet Chairman; Ned Arthur, Vice Chairman of Field Trips; Richard M. Stewart; and N. A. D'Arcy, Jr., Chairman of the Southern California Section.

and a Round Table Discussion was held Wednesday morning.

It was unanimously agreed that the Southern California Local Section did themselves proud, and spared no effort or expense to make the Annual Meeting one that will long be remembered. The General Committee under the Chairmanship of Henry T. Mudd, with Nicholas A. D'Arcy, Jr., and Basil P. Kantzer as Vice-Chairmen, C. W. Six, Treasurer, and Blair W. Stuart, Secretary; Finance Committee, with James D. Hughes, Chairman; Welcoming Luncheon Committee, A. C. Rubel, Chairman; Reception Committee, William H. Geis, Chairman; Cocktail Party Committee, Samuel F. Bowlby, Chairman; Dinner-Smoker Committee, Kenneth B. Powell, Chairman; Informal Dance Committee, Thomas F. Edson, Chairman; Banquet Committee, Ian Campbell, Chairman; Registration Committee, Frederic S. Boericke, Chairman; Technical Sessions Arrangements Committee, Lawrence W. Chasteen, Chairman; Hotel Committee, John R. Pemberton, Chairman; Student Participation Committee, Paul Andrews, Chairman; Publicity Committee, Robert L. Minckler, Chairman; and Field Trips Committee, Henry Mulryan, Chairman; and all committee members, did an outstanding job.

Statistics presented by William B. Plank, Professor Emeritus of Mining, Lafayette College, at the Education Div. meeting showed that 9453 students in U. S. schools are preparing for mineral industries positions. It represents an increase of 8.3 pct compared with the previous year and with an increase of 6.6 pct in total engineering enrollment. However, mining engineering enrollment fell 12.7 pct while ceramic engineering declined 13.2 pct. Petroleum leads, with metallurgy running third. Only 344 seniors in mining engineering are registered throughout the U. S.

Reasons offered for the scarcity of mining engineering students were low and uncertain metal prices, low starting salaries, and slow advancement. L. M. K. Boelter, of the University of California at Los Angeles, defended a four year training program for the engineer with industry training the graduate in specific methods. The majority seemed in favor of basic engineering courses with specialization taken care of by graduate work.

Mineral Economics Div. session on the Paley report found A. O. Bartell, of the Pacific Northwest, suggesting a high rate for assessment work as an aid to the small miner. He felt that the higher rate would discourage claim sitters who in many instances tie up property without serious intent of working it. Kenneth O. Watkins of Oregon noted that patenting of certain claims often involved a delay of eight years and a cost in excess of $1000 per claim.

Commenting on the very nature of the session, Andrew Fletcher, 1953 AIME President stated the session itself was futile. He noted that the Administration is expected to "ditch" the Paley report. Mr. Fletcher indicated that his feeling was that the report was strictly of academic interest, not to be taken seriously. He suggested as a substitute for serious thought the recent conference on a sliding scale tariff for lead and zinc.

Minerals Industry Education Div. luncheon was well attended. Seated at the speaker's table from left to right are: J. D. Forrester; J. W. Vanderwilt; H. H. Power, 1953 MIED Chairman; President Fletcher; and Curtis L. Wilson.

One person at the session pointed out that the Department of Interior had done much shouting about fraudulent use of claims for the purpose of gaining timber rights, but the Department failed to enforce its legal right to evict such parties.

Geophysics

by T. Koulomzine

Geophysics Subdivision attendance at the two sessions composing the symposium on methods of geochemical exploration was outstanding. Nine papers were presented dealing with geochemical explorations for petroleum, copper, zinc, and uranium. Uniquely, opinion on the best paper presented gave the laurels to a lady member of the U. S. Geological Survey, Helen L. Cannon, who dealt with geobotanical methods of prospecting for uranium. Mrs. Cannon used excellent color slides of desert flowers, distribution of which is helpful in location of uranium, to illustrate her part of the program.

Two other sessions were devoted exclusively to geophysics, while a joint session with the Geology Subdivision was also largely composed of geophysical papers. Twenty-two authors presented 14 papers at the general sessions. Possibly the most animated discussion centered around F. W. Hinrich's paper, *Aerogeophysics and the Paley Report*. Another group of papers to attract considerable attention were those dealing with airborne radio-activity surveying of the Colorado Plateau. Slides showing the hair-raising canyon rim flying in the search for uranium were widely acclaimed. Audiences at sessions varied from 40 to 200 persons.

Seated at the speakers table during the Coal Div. luncheon are: L. E. Young, past President of the AIME; Ralph E. Kirk, 1953 Coal Div. Chairman; A. Lee Barrett, 1952 Chairman; David R. Mitchell, Coal Div. Secretary; J. B. Morrow, Institute Vice President; M. D. Cooper; and W. M. Bertholf.

Geologists Meet, Eat, and Beat Retreat

by Jack Melvin

Members of the Geology Subdivision had a busy time at the 1953 Annual Meeting. Some arrived in town for a three-day meeting of the Association of American State Geologists on Feb. 12, 13 and 14. Some were official representatives at the Council of Section Delegates meeting on Saturday, Feb. 14. A few attended the Board of Directors meeting on Sunday. Some were seen at the Sunday meetings of the Mineral Industry Education Div. at the University of Southern California.

Monday through Thursday they found plenty of activity in their own divisions, however, with some 33 quality papers divided among three sessions sponsored by the division, a joint session with the Engineering Geology Div. of the Geological Society of America and joint sessions with the Geophysics and Mining Subdivisions and the Industrial Minerals Div.

Concurrently the Society of Economic Geologists sponsored six important sessions. There was also the luncheon meeting of the Mining, Geology, and Geophysics Div.; the Mining Branch Dinner; the Annual Banquet of the Society of Economic Geologists; the All-Institute activities and the pleasant hikes through the Los Angeles canyons between the Biltmore, Statler, and Mayfair Hotels. Finally, some of the members tapered off with the field trips.

The Tuesday morning session was devoted to applied geology. John S. Vhay reminded us of the important role the geologist can play in ex-

The Industrial Minerals Div. Luncheon was another outstanding event among the many and varied events of the week. Seated at the speakers table from left to right are R. E. Byler, past Chairman of the Mining Branch Council; J. L. Gillson; Katherine Mather, Pauline Moyd; President Andrew Fletcher; H. LeRoy Scharon, Chairman of the Mining Branch Council; and A. B. Cummins; Standing, R. S. Lund; J. J. Norton, Oliver Bowles; Harold Bannerman, 1953 Div. Chairman; Ian Campbell, outgoing Chairman; A. Lee Barrett, past Chairman of the Coal Div.; R. M. Foose; and M. F. Goudge.

MBD ACTIVITIES AT LOS ANGELES

Below, Ralph E. Kirk, whose Scottish forebears suited him to the job, served as toastmaster for the Scotch Breakfast, hallmark of the Minerals Beneficiation Div.

E. H. Crabtree, outgoing chairman of the Minerals Beneficiation Div., center, turns over the duties of office to D. W. Scott, 1953 Division Chairman, while President Andrew Fletcher looks on.

Below, W. B. Stephenson can be seen in the background while a Scottish coleen serenades and plays her accordian during the Minerals Beneficiation Div. Scotch Breakfast.

E. H. Crabtree, left, is declared Millman of Distinction by E. H. Rose, while T. B. Counselman and R. E. Byler look on approvingly. The degree is awarded each year to the outgoing chairman of MBD.

Minerals Beneficiation Div. held its annual business meeting outdoors in the Hotel Statler Patio, with a background of orange trees and other California foliage.

ploration by describing the work in the Black Bird Cobalt District of Idaho. Crossing the line into Montana, Edward P. Shea described the preliminary sampling of the Greater Butte Project.

J. K. Gustafson and A. E. Moss then led the expedition into the far north for a view of geologists working in the vast Labrador-Quebec iron ore districts. It was obvious from their presentation that the geologist has made a major contribution to this new source of raw material for our industrial way of life. The session closed with an important paper by Harrison Schmitt on those factors which are most critical in the modern valuation of a mineral deposit.

Applications of geology to lead-zinc-uranium deposits held the spotlight of the Tuesday afternoon session. Starting near home, M. B. Kildale described the influence of structural geology and stratigraphy on ore development in the War Eagle mine, Inyo County, California. Structural geology and stratigraphy also played a leading role in the discovery of zinc-lead ore bodies in the Wisconsin-Illinois-Iowa District, according to Allen F. Agnew. His paper also called attention to geochemical prospecting as a possible guide to ore in the district. The lead-zinc theme was continued in the paper by W. C. Kelly and Charles H. Behre, Jr., which was a progress report on the search for additional leached outcrop criteria useful in exploring for these important metals.

Uranium is still the glamour word in technical discussions, as well as in the popular press. "Hydrothermal Alteration Accompanying Tertiary Uranium Deposits" was the six-word title of a five-author paper by Kerr, Brophy, Dahl, Green and Woolard. This very interesting meeting was concluded with a paper by Charles A. Rasor which contained a description of the geology of the Colorado Plateau uranium deposits.

The Wednesday morning meeting concentrated on application of geology to the field of civil engineering. This part of the program was a joint session with the Engineering Geology Div. of the Geological Society of America and was well attended by civil engineers, as well as geologists.

The Wednesday afternoon meeting was termed a general session. A paper by Arthur Baker, III described localization of pyrometasomatic ore deposits at Johnson Camp, Ariz. Nevada next received attention as Alan T. Broderick showed how wall rock alteration was used as a guide to exploration.

Olaf P. Jenkin, State Geologist of California, described the mineral industries, and the session closed with a similar description of the mineral industries of Algeria, French North Africa, by Monsieur Richard Anderson.

Second Annual Pacific Northwest Conference at Seattle Includes All Metals Divisions; Meeting Scheduled for May 14 to 16

The Second Pacific Northwest Conference, inaugurated last year out of a desire to serve the industrial expansion of that region, will be held May 14 to 16 at Seattle's Benjamin Franklin Hotel. Once a one day meeting, the gathering of the Industrial Minerals Div. and the Metals Branch has grown rapidly in scope. Sponsored by the AIME branches, divisions, committees, and supported by members, a cordial invitation has been extended to all mining and metallurgical people to attend.

Many excellent papers will be found in the Extractive Metallurgy and Physical Metallurgy Sessions.

Electric furnace men in the Pacific Northwest area will be especially interested in the Iron & Steel Session. In keeping with the special effort to attract and encourage students to the conference, mineral and metallurgical industries in the area are providing funds to pay for student luncheons and banquet. Students will not be charged a registration fee.

Engineering Education round table conference will cover the trend toward inclusion of additional fundamental science, especially physics, chemistry, and mathematics in metallurgical curricula. Representatives from government and private industry, cognizant of the needs of physical metallurgy, chemical metallurgy, and mineral dressing, will participate.

The Get Acquainted Coffee Hour will sound the opening note in the round of activities planned for the Women's Auxiliary. A theater party has been arranged, along with a luncheon and style show.

One of the outstanding scheduled events will be the address by George Vincent, public relations officer of the Aluminum Co. of Canada, at the metals luncheon, Saturday, May 16. His subject will be *Alcan's British Columbia Developments*, dealing with the Kitimat-Kemano project now under construction. The Alcan project promises to be one of the world's major aluminum centers when completed.

THURSDAY, MAY 14

1:30 pm

Plant Visits

Pre-registration necessary. A choice of several will be available including, Boeing Airplane Co., Bethlehem Pacific Coast Steel Corp., Tacoma Smelter.

FRIDAY, MAY 15

9:00 am to 2:00 pm

Industrial Minerals Div.

Chairman: Milnor Roberts, Mining Engineer, Seattle, Wash.

Analytical Shortcuts by Use of the Spectrograph: Thomas Matthews, State Dept. of Geology and Mineral Industries, Portland, Ore.

Use of Fuels and Electricity in Industrial Minerals Operations in British Columbia: J. W. McCammon, Mineral Engineer, British Columbia Dept. of Mines, Victoria, B. C.

Reopening of the Wilkeson Property in Pierce County, Wash., to Produce Metallurgical Coking Coal: E. R. McMillan, Mine Production Engineer, Northwestern Improvement Co., Seattle, Wash.

Lightweight Aggregate Production from Pacific Northwest Clays and Shales: J. I. Mueller, Associate Professor, Ceramic Engineering, Howard Shapiro and Roger R. Riley, Fellows, Ceramic Engineering, University of Washington, Seattle, Wash.

Summary of the Industrial Minerals and Rocks and the Fuels of the Pacific Northwest Including British Columbia: Milnor Roberts, Mining Engineer, Seattle, Wash.

Natural Gas for the Pacific Northwest: H. R. Seykota, Products Sales Manager, Portland Gas & Coke Co., Portland, Ore.

Diatomaceous Earth in Washington: R. C. Vervaeke, Quincy Corp., Quincy, Wash.

9:00 am

Iron and Steel Div.

Chairman: James T. Gow, Chief Metallurgist, Electric Steel Foundry Co., Portland, Ore.

12 m

Industrial Minerals Luncheon

2:00 pm

Extractive Metallurgy Div.

Chairman: P. R. Benson, General Superintendent, Tacoma Smelter, Tacoma, Wash.

SATURDAY, MAY 16

9:00 am to 2:00 pm

Physical Metallurgy

Chairman: W. W. Wiltschko, Aluminum Co. of America, Vancouver, Wash.

12 m

Metals Branch Luncheon

Speaker: George Vincent, Public Relations Officer, Aluminum Co. of Canada

AIME Continues to Strengthen Financial Position As 1952 Surplus of $18,000 More than Doubles Previous Year

The following table indicates how the AIME income in 1952 was derived and for what purposes it was spent, both as to totals and on a per member basis. Notes following the table are intended further to clarify the data.

Income

	Total	Per Member	Pct of Income
1. Dues	$314,886	$15.28	53
2. Initiation fees	21,292	1.03	4
3. Advertising in journals	182,516	8.86	31
4. Sales of journals	28,135	1.37	5
5. Sales of Petroleum Statistics	1,917	0.09	—
6. Sales of Transactions volumes	28,942	1.40	5
7. Other sales	11,135	0.54	2
8. Interest	2,025	0.10	—
9. Miscellaneous	2,532	0.12	—
Total	$593,381	$28.80	100

Expense

	Total	Per Member	Pct of Expense
10. Local Sections	$17,736	$0.86	3
11. Divisions and branches	62,113	3.02	11
12. Institute activities	32,426	1.58	6
13. Library assessment	5,913	0.29	1
14. Journals	261,402	12.69	45
15. Transactions	17,597	0.85	3
16. Petroleum Statistics	2,220	0.11	—
17. Directory	20,542	1.00	4
18. Other publications; reprints	9,467	0.46	2
19. Secretary's office	32,464	1.57	6
20. Business office	71,116	3.46	12
21. Pensions, etc.	12,293	0.60	2
22. Insurance	592	0.03	—
23. Furniture and fixtures	6,869	0.33	1
24. Miscellaneous	22,565	1.09	4
25. Total	$575,315	$27.92	100

In the tabulation, the per member data are obtained by dividing the total amounts by 20,607, a figure that includes 1964 Student Associates.

1. This includes all the cash dues received from new and old members of all grades.

2. All cash initiation fees received from new members and partial payments on outstanding balances of men elected previously.

3. Net income received from advertising in the three monthly journals, of which $94,810 came from Mining Engineering, $50,670 from Journal of Metals, and $37,036 from Journal of Petroleum Technology. In 1951 the figures were, respectively, $72,273, $39,844, and $31,564.

4. Individual sales of current and back issues, nonmember subscriptions, and multiple member subscriptions.

5. Cash received from the sale of this volume.

6. Sales of current and old volumes of Transactions. In the case of old volumes a deduction of $1.60 as a credit to inventory is made.

7. Sales of all other printed matter except special volumes sponsored by certain Funds in which case the Fund is credited with the income less a handling charge. Includes a considerable sale of preprints and reprints of technical papers.

8. Interest on securities held by the AIME and income from the Hayden Fund; does not include dividends and interest from certain Funds whose income reverts to those Funds.

9. Voluntary contributions, net income on outside book sales, cash discounts taken on bills paid, minor items.

The total income compares with $522,076 in 1951, an increase of $71,305.

10. Consists of appropriations to Local Sections; traveling expenses of delegates from Local Sections to the Annual Meeting; and a rebate of $2 of the initiation fee paid by any new Member or Associate Member (not including changes of status) in areas embraced in Local Sections.

11. Includes all appropriations made to Divisions and Branches, and salaries and expenses of paid Division and Branch officers; salaries and expenses of the Field Secretary in Salt Lake City; and rental paid for office space in Dallas and New York used by Branch Secretaries and their staffs.

12. Includes salaries, expenses, and rental space occupied by the staff at Institute headquarters devoted to securing new members and processing and filing all applications; also the net cost of meetings not properly chargeable to Branches, Divisions, or Local Sections, or borne by them.

13. Net AIME contribution to the support of the Engineering Societies Library. The balance of the Library assessment comes from interest on the James Douglas Library Fund of $106,000, amounting to $4500.

14. Includes salaries and all expenses of the editorial and advertising staffs of the three journals; rental of office space used by the staffs; paper, printing, binding, and mailing. Net cost can be obtained by subtracting items 3. and 4. from 14.

15. Cost of printing, binding, and mailing the current year's Transactions volumes, plus a percentage of the salaries of those concerned with their production. This is approximately the income received from sale of these volumes, included in the total of item 6.

16. A part of the cost of producing the volume; most of the remaining cost met from the Special Projects Fund of the Petroleum Branch.

17. Cost of printing and distributing the Directory supplement issued last June; cost of renting Flexoprint machines, salaries, labor of installation; estimated cost of printing and distributing Directory mailed with January 1953 journals. (Future Directories should cost about half this.)

18. Covers making reprints of papers appearing in the monthly journals, supplied free to authors and for sale.

19. Salaries, travel, and incidental expenses of the Secretary's office; rental of space used.

20. Salaries, rental, and miscellaneous expenses of the Business Office, including accounting, Addressograph (in part), filing, orders, change of address, purchasing, shipping (in part), reception, duplicating, and Flexoprint operations. In some instances a part of these expenses are charged to other items of expense.

21. Pensions and annuities, and certain severance payments for the staff are included. Noncontributory insurance and annuity policies are carried for AIME employes of more than five years' service. Income from any canceled policies is credited to this item.

22. Various types of insurance are carried.

23. Major items of furniture and fixtures are capitalized and during 1952 10 pct depreciation was charged on new equipment purchased. On old equipment, 20 pct depreciation was charged in this item.

24. Major items in this account were: Postage and supplies, $4762; write-off to accounts receivable (much of which it is hoped can be collected), $3691; New York disability taxes, Blue Cross subscriptions for staff members, and AIME share of Social Security taxes, $3723; labor expense (nonrecurring) in in-

stallation of new Addressograph system and cutting and tabbing some 21,000 new stencils, $3164; rearrangement of offices and partitions, construction, $2009; maintenance on furniture and fixtures, $1502; printing and inserting certain material in envelopes, $1320.

25. Compares with $514,067 in 1951, or an increase of $61,248. Major item in the increase was the cost of the Directory, which was not published in 1951.

It should be noted that the dues received per member are about $5 less than the dues paid by Members and Associate Members. In other words, the members in those two classes, who pay $20, are subsidizing to a certain extent the Junior Members who pay $12 dues but who receive all the privileges of membership; Student Associates, who pay only $4.50; Senior Members (of at least 30 years' standing and over 70 years old, who apply for this grade and who pay no dues at all but receive all privileges); and Honorary Members, who likewise pay no dues.

AIME Directors' meetings in the coming year will be held as follows:

Mar. 18, 1953, 12:30 pm	Executive and Finance Committees	New York
Apr. 15, 12:30 pm		New York
May 13, 10 am	Board of Directors	Tulsa
June 17, 10 am		New York
July 15, 12:30 pm	Executive and Finance Committees	New York
Aug. 19, 12:30 pm		New York
Sept. 22, 6 pm	Board of Directors	Seattle
Oct. 21, 12:30 pm	Executive and Finance Committees	New York
Nov. 18, 10 am	Board of Directors	New York
Dec. 16, 12:30 pm	Executive and Finance Committees	New York
Jan. 20, 1954, 12:30 pm		New York
Feb. 14, 2:30 pm	Board of Directors	New York
Feb. 16, 5 pm		New York

Bylaw Change Proposed

Pursuant to Art. XII, Sec. 1, of the Bylaws of the AIME, the following change in Art. II, Sec. 3, proposed by the Board at its February 15 meeting is hereby published for the information of members:

Present wording: Any Member or Associate Member may become, by the payment of $300 at one time, a Life Member or Life Associate Member and shall not be liable thereafter to pay annual dues. The money thus received shall be invested and only the income thereof used for current expenses of the Institute.

Proposed wording: Any Member or Associate Member may become, by payment at one time of twenty times the current normal annual dues for the grade in which he is enrolled, a Life Member or Life Associate Member, according to his current status at the time application is made. He shall not be liable thereafter to pay annual dues.

The Board will vote on this change at its meeting on May 13.

Name H. DeWitt Smith President-Elect for 1954

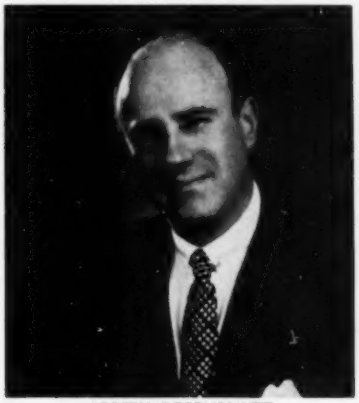
Henry DeWitt Smith was named President-elect for 1954 by the Nominating Committee for AIME Officers in 1954, S. S. Clarke, chairman, which met in Los Angeles on February 18. If elected, he will succeed L. F. Reinartz, who will serve as President in 1954. Other nominations of the Committee were as follows: For Vice-President, T. B. Counselman and Harold Decker; and for Director, Ralph E. Kirk, Carleton C. Long, P. J. Shenon, George D. Dub, E. R. Marble, and E. C. Babson.

Mr. Smith is vice-president of the Newmont Mining Corp., with headquarters in New York. He served as Director of the Institute, 1941-42.

Brief biographical sketches of the nominees will be published in the July issues of the journals. No letter ballot will be mailed to members unless supplementary nominations are received by September 1.

Personals

N. A. STOCKETT



JOSEPH ROSENBLATT

WESTON G. THOMAS

N. A. Stockett has retired as general mill superintendent of the Southeast Missouri Div. of the St. Joseph Lead Co. and will continue to reside in Bonne Terre, Mo. Before starting with St. Joseph Lead in 1916, he worked at Butte and in Ontario, British Columbia and the Coeur d'Alenes. The last 36 years were spent in the mining and milling dept. of St. Joseph Lead. Mr. Stockett served overseas as a lieutenant of engineers in World War I. In 1948 he was chairman of the St. Louis Section of AIME.

John L. Christie is now manager of the metallurgical dept. of Handy & Harman Co. He was formerly metallurgical manager of this company.

M. E. Defoe was promoted to mill superintendent of the Chelan Division of Howe Sound Co. Mr. Defoe was formerly metallurgist.

Carl Gommel has been appointed to the engineering staff of the Colorado School of Mines Research Foundation. A student at the Colorado School of Mines from 1926 to 1928, he later spent two years at the Mackay School of Mines. He also attended the Academy of Science and Arts in Rio de Janeiro, Brazil, from which he received a Ph. D. degree in chemistry.

Merle H. Guise is on his second examination in Brazil in the last year. Present visit is to study natural resources for large Brazilian interests. He expects to complete examinations in April and return to N. Y.

Paul B. Jessup has been appointed assistant treasurer of Kennecott Copper Corp. He resigned his position as vice-president of Day Mines, Inc., at Wallace, Idaho to assume his new duties at Kennecott's executive offices in N. Y. C.

Robert B. Mahan has been appointed general superintendent of Baguio Gold Mining Co.

Joseph Rosenblatt, president of Eimco Corp., has been named chairman of the Salt Lake City branch, Federal Reserve Bank of San Francisco. Mr. Rosenblatt is a member of the Salt Lake City Chamber of Commerce, Utah Mfg. Assn., and a director of the manufacturing division of American Mining Congress.

H. W. Franz has left Kaiser Aluminum & Chemical Corp. and is now plant manager of Colonial Aluminum Smelting Corp. in Colombia.

Weston G. Thomas, director and treasurer of Climax Molybdenum Co., New York City, has been elected vice president.

R. Livingston Ireland of Cleveland has been elected a director of the Phelps Dodge Corp. to fill the vacancy created by the resignation of George M. Humphrey, now secretary of the Treasury. Mr. Ireland is chairman of the executive committee of the Pittsburgh Consolidation Coal Co. and of the M. A. Hanna Co. He also is a director of the National Steel Corp. and the Union Bank of Commerce Co. of Cleveland.

Personals, Cont'd

Simon D. Strauss has been elected to the board of the American Smelting & Refining Co. He has been with AS&R since 1945 and has been a vice president since 1949.

Robert H. Nelson and **Irving G. Irving**, mining geologists and operators of the Norwich, Plutus and other manganese (rhodochrosite) properties in the western part of Butte, have announced their partnership as geological consultants, with offices in the Hirbour Bldg., Butte. Mr. Irving was geologist for the Galigher Co. during the past two years and previous to that was an independent consultant and operated the Quartz Hill mines near Divide, Beaverhead, County, and the Pyrenees mine near Georgetown, Deer Lodge County. Mr. Nelson operated the Two Percent mine in Philipsburg and in 1941 joined the Reconstruction Finance Corp. as principal engineer in Washington, D. C. In recent years he has been in charge of the mining division of the RFC at Helena.

J. S. Mitchell was transferred from the Chelan Div. of Howe Sound Co., where he held the position of mill superintendent, to the Calera Mining Co. refinery, Garfield, Utah, where he assumes the position of assistant superintendent.

O. D. Niedermeyer was appointed vice-president and general manager of the Nickel Processing Corp., Nicaro, Oriente, Cuba. He was also made a director of this company. The appointment was made by the Board of Directors of the Nickel Processing Corp. and confirmed by the Magnesium and Nickel Committee.

E. D. Powers was elected president of the Chemical Construction Corp., a subsidiary of American Cyanamid Co. He remains vice president and director of the parent firm. Mr. Powers, who has also been elected a director and member of the executive committee of the corporation, has been with Cyanamid since 1918.

Myron Read has been appointed plant manager of the Fort Dodge, Iowa, gypsum plant of the Certain-teed Products Corp. Mr. Read joined this company in 1945 as a mining engineer at their gypsum plant in Akron, N. Y.

Fred Robertson was promoted to the position of mine foreman at the Chelan Div. of Howe Sound Co.

J. Fred Johnson who retired from active service with the American Smelting & Refining Co. on Jan. 1, 1953 has gone to Sweden on consulting work and will also do some work for the U. S. Army in Ireland.

Dean Edward Steidle of the School of Mineral Industries of The Pennsylvania State College is to retire on June 30 from the position which he has held with success for the past 25 years. Internationally-known for his work in mineral industries, Dean Steidle represented Pennsylvania at the first Pan-American Congress of mining engineering and geology in Santiago, Chile in 1942; lectured in South America under the sponsorship of the Inter-American Development Commission in 1944; represented the U. S. Dept. of State at the second Pan-American Congress of mining engineering and geology in Rio de Janeiro, Brazil, in 1946 and was elected vice-president of the congress; and was delegate for the AIME to the United Nations Scientific Conference on the conservation and utilization of resources.

To honor the Dean for his long and distinguished service to the mineral industries, industrial leaders, alumni, faculty, and students will join at the annual "Mineral Industries Student-Faculty Banquet" to be held at the Nittany Lion Inn, at State College, on Saturday, May 2, 1953. The toastmaster will be George H. Deike, chairman of the board of the Mine Safety Appliances Co., and vice-president of the Board of Trustees of the college.

Obituaries

Frederick R. Mitchell (Member 1941) died on April 28, 1952. Graduated from the Michigan College of Mines with an E.M. degree, he had a long and varied career in the mining and milling field. One of his earlier positions was as an assistant in the geological dept., Cleveland Cliffs Iron Co., Ishpeming, Mich. He was an officer in the U. S. Naval Reserve Flying Corps during World War I. He did research work at the experiment station at the University of Illinois. One of his later positions was division engineer with Tennessee Coal, Iron & R. R. Co. in Birmingham, Ala. Mr. Mitchell was born in Marquette, Mich.

Manuel Burr Lovelace (Member 1927) died on April 11, 1952. Mr. Lovelace was born in Los Angeles and educated at Stanford University where he received an A.B. and E.M. degree. He worked for Cerro de Pasco as mine shift boss in Lima, Peru. Mr. Lovelace did mine examination work for a short period of time. The Nevada Consolidated Copper Co. employed him as an assayer at their Ruth mine. From June 1933 to September 1935 he was manager of the Egan Mines, Inc., Cherry Creek, Nev. Later on he held a position as manager of Gold Canyon Mining Co. in Patagonia, Ariz. His last position was with American Smelting & Refining Co. as a superintendent of their Trench mine in Arizona. He was affiliated with the Mining, Geology, & Geophysics Div.

Henry M. Hartmann (Member 1926) died on Aug. 17, 1952. Mr. Hartmann had been employed by numerous mining companies. One of his earlier positions was with Consolidated Mining Co. in Butte, Mont., as assistant engineer. He was general manager of Ophir Hill Consolidated Mining Co. Mr. Hartmann worked in Forney, Idaho as a mining engineer for the Jacket Mine, Conder Gold Mining Co. Born in Dianesburg, N. Y., he received a B.S. degree from Yale University.

Henry S. Young (Member 1903) has died. Mr. Young was a life member of AIME. He was on Legion of Honor list for the class of 1903. He was at one time manager of the Bornee Co., Ltd. in Dutch East Indies. His last address was Invergordon, Rosshire, Scotland.

W. Frank Lewis (Member 1914) died on July 12, 1952. Mr. Lewis had a long and varied career in the mining industry and worked for many well-known mining companies, among them Cleveland Cliffs, Shannon Copper Co., and Chino Copper Co. He had experience in dredging, steam-shovel mining and underground mining. Born in Sand Lake, Mich., he attended a business college in Big Rapids, and Michigan College of Mines. He held B.S. and E.M. degrees.

Whitman Symmes (Member 1910) died on December 3, 1952. Mr. Symmes was superintendent of the California Borax Co. at Searles Lake, Calif. He was connected with constructing Manila Harbor while he was manager of the Atlantic Gulf & Pacific Co. One of his later positions was with Acme Mining Co. in California and Alaska. Mr. Symmes wrote many articles for various mining magazines. Educated at the University of California and Harvard University, he had an A.B. degree.

K. B. Swamy (Member 1949) has died. Mr. Swamy was born in Gajapatinagarum, Madras, India. He had worked for Consolidated Tin Mines of Burma as surveyor and later became manager. Mr. Swamy lectured in surveying at Indian School of Mines and he was an assistant mining engineer for the Geological Survey of India. He was a professor of mine surveying at Banaras Hindu University, Banaras. Mr. Swamy attended St. Xavier's College, Indian School of Mines, and the Royal School of Mines. He was a member of the Mining, Geological and Met-

allurgical Institute of India and an associate of the Institution of Mining and Metallurgy, London.

William Ryer Wright (Member 1917) died on November 26, 1952. Born in New York City, Mr. Wright was educated at Columbia University, School of Mines, where he received an E.M. degree. He was an assistant mine engineer with Braden Copper Co. in Chile and was a construction and chemical engineer with Aetna Explosives Co. in New York. One of his latest positions was with the firm of Ford, Bacon & Davis, Inc. of Chicago, Ill. Mr. Wright devoted much of his time and energy to the Engineering Center of Columbia University. He was also past chairman of the Chicago Section of AIME.

Allan M. McDermott (Member 1921) died. Born in Teeswater, Ont., he was educated at Ohio Northern University where he studied civil engineering. Mr. McDermott was principal of a high school in Marengo, Ill. and was then made superintendent of schools. His mining career began in 1901 when he accepted a position with Phelps-Dodge Co. in their Copper Queen Branch. He received his degree as a mining engineer from the Ohio Northern University.

Appreciation of
Walter Landon Maxson

By Everett H. Parker

Walter Landon Maxson, M.E. 1915, died Jan. 8, 1953, in St. Joseph's Hospital, Bellingham, Wash.

Suffering ill health for the past year, he had been spending a vacation on Orcas Island in Puget Sound with his wife when he contracted pneumonia and was taken by airplane to Bellingham for treatment.

Walter, recognized as one of the most well-known mining and metallurgical research men in the world with a wide knowledge of raw materials and beneficiation, was appointed a member of the Atomic Energy Commission, to serve as a consultant on the raw materials committee.

He was one of the few graduates of Cornell to enter directly into the mining profession. In the 37 years following graduation, business took him all over the world, gaining for him recognition as a metallurgist of national and international prominence.

Born in Cortland, N. Y., Sept. 17, 1892, where he received his elementary education, he enrolled at Cornell in 1911. Taking advantage of the mining courses he earned the degree of Mechanical Engineer, which was conferred on him in 1915.

The first phase of his career embraced six years in the fields of operation and research in the U. S. and foreign countries, with Anaconda Copper Mining Co. in Chile, Amalgamated Zinc Co. in Australia, and Phelps-Dodge and New Jersey Zinc in this country.

This background experience in mining, mineral dressing, hydro and pyroprocessing of both metallic and nonmetallic ores attracted the Colorado School of Mines, where he served for some six years as associate professor of metallurgy. During this period at the school he earned his M.S. degree in metallurgy. Last year Colorado School of Mines decided to give him "The Award of Merit" for outstanding service to his profession, but because of circumstances he was not able to be present, and the award was not officially conferred.

In 1927 he entered the commercial engineering field, joining the Allis-Chalmers organization as engineer in the mining dept. and later was advanced to chief engineer. From that time on promotions came in rapid succession progressing to sales manager and chief engineer of the mining, crushing and concentrating div. and eventually he became manager of the basic industries dept.

He participated in the development of gold mines all over the

world, ranging from Arabia through Indo-China and the Philippines, in Chile and South Africa, tin in Bolivia and the East Indies, bauxite in the Guianas, copper, lead and zinc throughout the world, iron ore in Alabama and the Adirondaks, uranium in the Arctic Circle.

In 1944 the U. S. Steel Corp. inaugurated a long-range research program under the auspices of its subsidiary, the Oliver Iron Mining Co., to improve its raw materials and conduct experiments with taconite. When plans were made for the establishment of a large research laboratory at Duluth, Walter was selected as its director. In 1946 he was made vice president-research for the company and had since directed its taconite development program which is now approaching consummation.

Professionally Walter rose to the top and on the way made friends throughout the world. He did not let his penetrating mind interfere with his sense of humor. Drawing simultaneously on his pipe and his experiences in many lands as a story teller he was unsurpassed.

Walter was a member of the AIME, University Club of Milwaukee, Duluth Rotary, the Masonic fraternity and St. Paul's Episcopal Church, Duluth.

Walter is survived by his wife, nee Helen M. King, of Anaconda, Montana, and a son, Richard K., now serving with the U. S. Navy.

In his passing Cornell has lost a loyal alumnus; his profession, a leader; his friends, a cherished companion; and his family, a devoted husband and father.

NECROLOGY

Date Elected	Name	Date of Death
1940	Fred J. Bailey	Jan. 16, 1953
1948	Richard J. Barnes	Unknown
1899	John Cabot, Jr.	Dec. 8, 1952
1949	R. H. Clark	Nov. 24, 1951
1900	Howard N. Eavenson	Feb. 16, 1953
1951	John H. Gillies	Jan. 21, 1953
1896	Meade Goodloe	June 2, 1952
1940	John Harvey	January 1953
1947	Clyde T. Holmes, Jr.	Unknown
1936	Daniel B. Johnson	Aug. 16, 1952
1898	W. J. Loring	Oct. 8, 1952
1891	Arthur C. Payne	Nov. 13, 1952
1949	J. Irving Prest	May 29, 1952
1939	Charles F. Redmon, Jr.	August 1952
1935	Walter Riddell	Unknown
1921	Warren A. Sinsheimer	November 1952
1913	J. H. Steinmesch	Dec. 15, 1952
1938	F. E. Turton	Dec. 21, 1952
1952	Ward Tuttle	Nov. 30, 1952

Proposed for Membership

MINING BRANCH, AIME

Total AIME membership on Feb. 28, 1953 was 18,262; in addition 2,008 Student Associates were enrolled.

ADMISSIONS COMMITTEE

O. B. J. Fraser, Chairman; Philip D. Wilson, Vice-Chairman; F. A. Ayer, A. C. Brinker, R. H. Dickson, Max Gensamer, Ivan A. Given, Fred W. Hanson, T. D. Jones, George N. Lutjen, E. A. Prentis, Sidney Rolle, John T. Sherman, Frank T. Sisco, R. L. Ziegfeld.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

Alabama
Bessemer—McEniry, Ralph W. (R. C/S—S-A)
Birmingham—Gegg, Edgar J. (J)
Birmingham—Reed, Daniel J., Jr. (J)
Birmingham—Weed, James K. (M)
Lipscomb—Zukow, Peter J. (R. C/S—J-M)

Arizona
Morenci—Moolick, Richard Terrence (C/S—J-M)
Tucson—Barber, George A. (R. C/S—S-J)
Tucson—Hess, Louis B. (C/S—S-J)

California
Grass Valley—Wilson, Francis L. (C/S—A-M)
Los Angeles—Opley, Mabel S. (A)
Pasadena—Hoylman, H. Wayne, (M)
Piedmont—Hale, Elwyn C. (A)
Piedmont—Oliver, Edwin L., Jr. (A)
San Francisco—Schneider, Frederick V. (R. C/S—J-M)

Colorado
Denver—Allen, Thomas (R. M)
Denver—Daman, Arthur C., Jr. (J)
Denver—Kunde, Marvin A. (C/S—S-J)
Denver—Wilfley, George M. (A)
Grand Junction—Teichman, Richard A., Jr. (J)
Nucla—Gaggini, Louis P. (C/S—A-M)
Pueblo—Hurst, Robert M. (C/S—S-J)
Telluride—Rumpf, Vincent G. (C/S—J-M)
Uravan—Stokes, Earle B. (C/S—S-J)

Connecticut
New Canaan—Behre, Merrill Clifford (J)
Westport—Flagg, Richard W. (C/S—A-M)
Westport—Hart, Harry F. (C/S—S-J)

District of Columbia
Washington—Butler, Robert S. (R. M)
Washington—Houk, Lawrence G. (R. M)

Florida
Bartow—Clawson, Floyd J. (C/S—A-M)
Bartow—White, Frank E. (J)
Lakeland—McGarry, Phillip E. (R. C/S—A-M)

Illinois
Alton—Kehr, Edwin A. (R. C/S—S-J)
Chicago—Matkovic, Mijo (M)
Evergreen Park—Appleton, James A. (R. C/S—J-M)
Rosiclare—Wrobbel, Fred C. (C/S—A-M)

Kentucky
Belfry—Schlickau, Joseph A. (M)
Leatherwood—Wender, James D., Jr. (M)
Lynch—Felton, James O., Jr. (J)
Madisonville—Knight, Herman E. (R. C/S—S-M)
Wheelwright—Lockin, George (C/S—S-J)

Louisiana
Port Sulphur—Monroe, John E. (M)

Michigan
Crystal Falls—Ford, Robert B. (J)
Ishpeming—Sundeen, Curtis R. (R. M)

Minnesota
Duluth—Adams, Malcolm (M)

Missouri
Bonne Terre—Suter, Cecil H. (J)
Joplin—Schoenberger, Pope (M)

Montana
Butte—Graves, Arthur J. (C/S—S-J)
Butte—McNabb, John S., Jr. (R. C/S—S-J)
Butte—Suttie, John McGilvary (M)
Butte—Unger, Walter H. (C/S—S-A)
Helena—Nelson, Robert H. (R. M)

Nevada
Blue Diamond—Dempsey, John P. (C/S—A-M)
Reno—Anderson, Andrew E. (M)
Reno—Wells, Howard A. (A)

New Hampshire
Merrimack—Carlson, Roger M. (J)

New Jersey
Franklin—Mitchell, Steve (R. C/S—S-J)
Merchantville—Cole, Irving A. (M)

New Mexico
Bayard—Newell, Oliver Jarris (C/S—A-M)

New York
Brooklyn—Schiff, Seymour (J)
Eggertsville—Jacobs, Charles W. F. (C/S—A-M)
Elmhurst—Robinson, Jesse M. (M)
Huntington—DiGregorio, Vincent (C/S—S-J)
Oakfield—Mason, Albert P. (C/S—S-J)
Rye—Aries, Robert S. (M)
Schenectady—Ketner, Richard deZ. (M)

North Carolina
Durham—Heron, Stephen D., Jr. (J)

Ohio
Columbus—Peterson, Marius S. (C/S—S-J)
Columbus—Smith, William H. (C/S—A-M)

Oklahoma
Norman—Ham, William E. (M)

Pennsylvania
Philadelphia—Reese, Lemuel V. (R. M)
Pittsburgh—Kennedy, John A. (M)
Pittsburgh—Love, George H. (M)
Pittsburgh—Rains, Phillip K. (C/S—S-J)
Pittsburgh—Walker, Joseph L., Jr. (R. C/S—J-M)
Pottsville—Bazley, James R., Jr. (C/S—J-M)
State College—Camacho, Walter (C/S—A-M)

Tennessee
Ducktown—Estabrooks, Henry B. (R. C/S—J-M)
Knoxville—Thompson, David A. R. (R. C/S—J-M)

Texas
Beaumont—Ronicker, Frederick J. (C/S—A-M)
Bellaire—McKinlay, Philip F. (C/S—A-M)

Utah
Midvale—Cunningham, William Ray (J)
Ophir—Barrett, Soren A. (C/S—A-M)
Salt Lake City—Bauer, Herman L. (C/S—S-J)

Virginia
Charlottesville—Rolston, John Albert (C/S—A-M)

Washington
Spokane—Anderson, Webster S. (C/S—S-J)
Spokane—Kilsgaard, Thor H. (C/S—A-M)
Spokane—Williams, Robert S. (C/S—A-M)

West Virginia
Bluefield—Lazer, Benjamin (M)

Wisconsin
Madison—Pugh, Myron E., Jr. (J)
Milwaukee—Kirkland, Terence G. (R. C/S—J-M)

Alaska
College—Hoskins, John R. (C/S—A-M)

Bolivia
Oruro—Varga Gallardo, Juan (M)

Brazil
Sao Paulo—Passos Guimaraes, Jose E. (C/S—A-M)

Canada
British Columbia—Russell, Dalton L. (C/S—S-J)
British Columbia, Vancouver—Snelgrove, William Richard (R. C/S—S-J)
Copper Cliff—Parlee, Jas. C. (R. M)
Manitoba, Flin Flon—Down, Richard F. (J)
Montreal, Quebec—Dyment, Arthur E. (M)
Ottawa, Ontario—Thunaes, Arvid (M)
Toronto, Ontario—Buffam, Basil S. W. (M)
Toronto, Ontario—O'Donnell, Keith (M)

Canal Zone
Margarita—Christoph, Vern Hewit (C/S—S-J)

Chih.
Naica—Knight, Edward T. (R. C/S—J-M)

Chile
Chuquicamata—Delaney, John Francis (J)

China
Hong Kong—Keay, William M. (M)

French Morocco
Casablanca—Budin, Francois (M)

Mexico
Chihuahua—Obregon, Antonio (J)

Peru
Cerro de Pasco—Babcock, George H. (J)
Cerro de Pasco—Bernstein, Merwin (J)
Lima—Rose, Erwin (J)

Spain
Prov. de Huelva—Marklew, Jack (M)

Drilling
Geophysicists
Management
Metallurgical
Reports
Valuations

—Coming Events—

Apr. 12-16, Electrochemical Society "Symposium on the Application of Electrochemistry to Biology and Medicine," Hotel Statler, N.Y.C.

Apr. 12-May 23, Empire Mining and Metallurgical Congress, Australia-New Zealand.

April 18, St. Louis Section Rolla meeting in conjunction with AIME Student Conclave, Missouri School of Mines campus.

Apr. 20-22, AIME, National Open Hearth and Blast Furnace, Coke Oven and Raw Materials Conference, Hotel Statler, Buffalo.

April 20-22, 1953 Metal Powder Show and Ninth Annual Meeting, Hotel Cleveland, Cleveland.

Apr. 25-May 10, Fifth Liege International Fair, Liege, Belgium.

May 11-14, American Mining Congress Coal Convention & Exposition, Public Auditorium, Cleveland.

May 14-16, Pacific-Northwest Metals and Minerals Conference of 1953, joint meeting of Metals Branch and Industrial Minerals Div., Ben Franklin Hotel, Seattle.

May 14-23, Thirtieth Anniversary International Petroleum Exposition, Tulsa.

May 18-22, Fifth National Materials Handling Exposition, Convention Hall, Philadelphia.

June 3-7, Chemical Institute of Canada, Windsor, Ont.

June 16-19, Exposition of American Welding Society, Shamrock Hotel, Houston, Texas.

June 16-19, Materials Conference held concurrently with First Exposition of Basic Materials, Hotel Roosevelt, New York.

July 13-16, Golden Jubilee of the Idaho Mining Assn., Sun Valley, Idaho.

Sept. 8-12, Joint Meeting Industrial Minerals Division, AIME, Keltic Lodge, Ingonish, Nova Scotia.

Sept. 21-23, American Mining Congress Mineral Mining Convention, Olympic Hotel, Seattle.

Oct. 8-9, Ninth National Conference on Industrial Hydraulics, Hotel Sheraton, Chicago.

Oct. 19-21, Institute of Metals Division, Fall Meeting, Hotel Allerton, Cleveland.

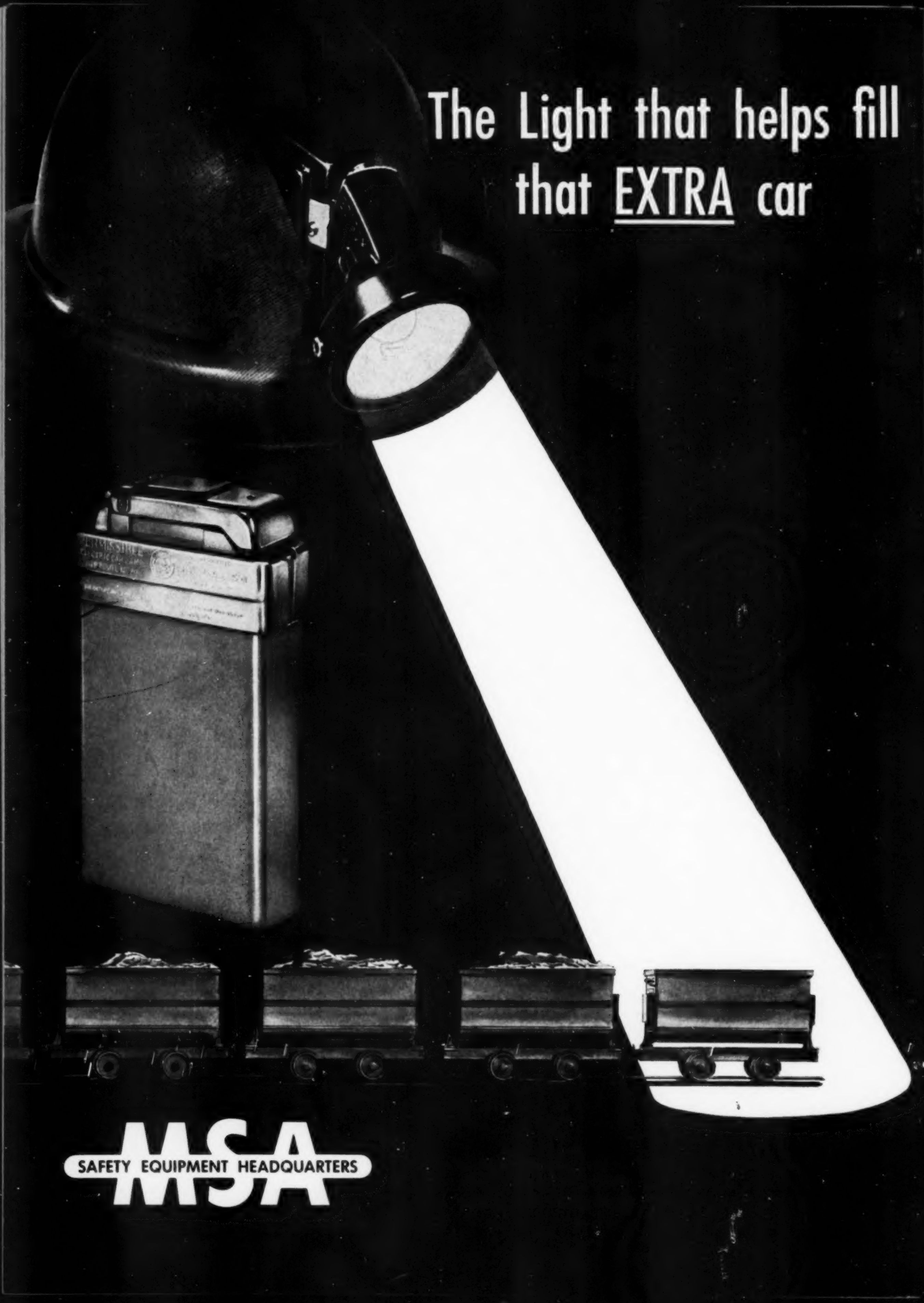
Oct. 28-31, AIME, El Paso Meeting, in cooperation with International Mining Days, Paso Del Norte, El Paso.

Oct. 29-30, AIME, ASME Fuels Conference, Conrad Hilton Hotel, Chicago.

Oct. 29-31, Annual Meeting of National Council of State Board of Engineering Examiners, Plaza Hotel, San Antonio.

Advertisers' Index

* Previous Issues


The Light that helps fill
that EXTRA car
MSA
SAFETY EQUIPMENT HEADQUARTERS